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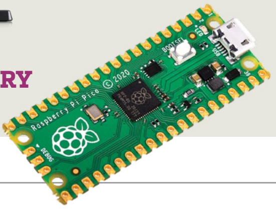

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TINKERING WITH 4K

I'VE GOT THAT ITCH again for a new system. Honestly, it's the biggest curse of this job. Once you're in, and you're tinkering and playing with hardware, and writing about it and building systems all the time, you sit down, and you're like "This is enough, I'm happy, Core i5-10600K, RTX 2080 Super, it's all good." Then things start launching; AMD releases new processors, Nvidia announces new GPUs, performance increases over here, new awesome software and tech out over there, then a few cool-looking cases pop up. All of a sudden your mind is back on the idea of liquid-cooling the proverbial out of some poor chassis that's likely going to have its front I/O cut out because it looks "aesthetically displeasing" to you. That is my life, and let's be fair I can't really complain about it, can I?

And so this issue we (I say "we," I really mean "I") decided to take things out for a test drive so to speak, namely, by revisiting an old topic that we've explored several times over the years: 4K gaming. In fact, since I've been at *Maximum PC* this idea is something we've done time and time again, year after year. Not because we're fresh out of ideas, but because it's that halo product, the system that we all want to see make its way down to the mainstream, or at least become more affordable. And year after year, the prices decrease, the frame rates go up, and we get one step closer to leaving the world of 1440p and 1080p far behind.

With AMD's latest processors and GPUs launching, complete with Smart Access Memory and a bevy of other features, we've teamed up with Corsair to bring you one of the most epic-looking "off-the-shelf" luminous systems you can build and buy today.

On top of that we have some phenomenal content this month. In fact, I think this might be my favorite issue of all time. Ian's taking us on a nostalgic journey back in time to look at the Y2K Millennium Bug, and that includes some fantastic interviews with the UN's director of the International Y2K Cooperation Center, Bruce McConnell, alongside some other brilliant sources in the form of Peter De Jager and Richard Hassett, for a truly insightful look into what might have been. Then Dave gives us a full deep-dive and deconstruction of the SteelSeries Apex 7 TKL mechanical keyboard, soldering in his own mechanical switches by hand, and Jonni gives us the lowdown on not getting hacked, and how those pesky cyber-crims do it.

We've got more than that too, including a ton of tutorials, and reviews of the Ryzen 5 5600X, Sabrent Rocket 4.0 Plus PCIe SSD, an ultra-ultrawide 49-inch Samsung monitor, and the latest Raspberry Pi Pico microboard. Oh and *Cyberpunk 2077* is in for review too, and then of course we have all the latest and greatest columns from Jarred, myself, and the rest of the team. Seriously, this is my favorite issue ever, and I do hope you enjoy it too.

As always, stay safe out there, and until next time.

ZAK STOREY

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

World Chip Shortage

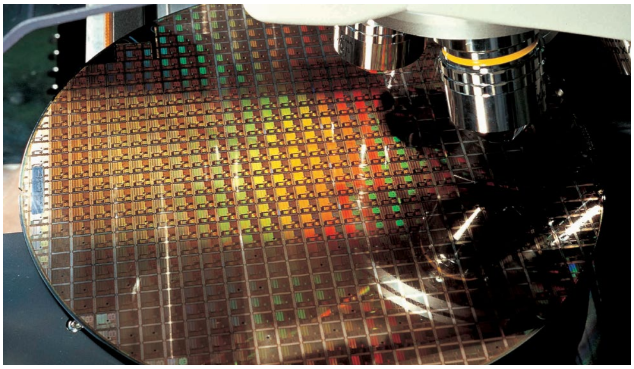
It's not a good time to shop for components

THE MODERN world runs on silicon—even if a product doesn't have chips in it, the machines that make it, deliver it, or supply the raw materials will. Manufacturing chips is expensive; the machines that make the wafers cost $100 million a pop. Such expensive machines are kept running continuously, and production runs are planned months in advance. Spare capacity is lost money, so the total capacity is close to total demand. If a manufacturer orders too few chips it can take a while until there's a production slot available to build more.

The pandemic has thrown a spanner into the works, and the industry is struggling to adapt. The result is a chip famine. This isn't unique—it happens regularly as part of the supply and demand cycle. But circumstances have combined to make this the worst yet.

It's not all the pandemic either. Problems were already brewing. Cutting-edge silicon is made on 300mm wafers, and the major players have switched to the larger size in search of higher yields and more profitable chips. However, there's still huge demand for simpler silicon using 200mm or smaller wafers. Here the technology is mature; costs are lower, but so are profits. The shift to high-value 300mm fabrication has left the total capacity at 200mm plants tight. Customers liked the simpler chips and had little incentive to move, so designs weren't ported to 300mm, with the costs that entails. A surge in demand for 200mm Bluetooth, 5G, Wi-Fi, and automotive chips caught the industry off balance.

> TSMC has said that rectifying the shortage of automotive chips is a priority



We even face a shortage of such basic devices as PWM controllers, and there are a lot of these used in all sorts of kit. Add COVID, which has changed the pattern of demand, and the problem's got much bigger.

The PC industry is struggling. Intel ran out of chipset chips, while AMD can't make enough Ryzens. Any small snag is significant. Micron's biggest memory plant suffered a power outage that trashed everything on the production line, and took days to fix. That one factory makes 10 percent of the world's DRAM. There's even a shortage of raw materials. Manufacturers are having to prioritize supply, so servers that run international business come first. Home consumer electronics are way down the list.

The automotive industry has been hit particularly hard. 40 percent of the cost of car manufacture is in the hundreds of chips they carry. Just about every major manufacturer has had to reduce car production, or let plants stand idle. The year had a poor start, and order books were expected to remain light, then sales unexpectedly recovered. Just when firms needed to reorder, demand for the chips surged from other sectors, including more profitable ones such as smartphones. The car makers were left out in the cold.

Apart from the more obvious shortage of computer components, this is the most striking victim of the drought. Worldwide, hundreds of thousands of workers are idle. TSMC has said that rectifying the shortage of automotive chips is a priority.

Shortages of the new Ampere and RDNA2 are notorious, but it's not just high-end cards where supplies are tight, it's in every sector of the market. Prices have risen across the board, and it's now difficult to buy a card at anything like the original recommended price, and even modest cards are selling for twice their original price. Rumor has it that Nvidia has restarted production of the RTX 2060 and 2060 Super to try and get more cards into the market. Bitcoin hasn't helped either—the recent spike in value has diverted GPUs away from playing games to mining coins. Nor has the global shortage of GDDR6 memory, which the high-end cards use.

The chip shortage is expected to last well into 2021. New 200mm wafer capacity is due to come online this year, but some sectors will take months to settle down. Don't panic though, the pandemic will pass, and manufacturing will catch up with demand, it always does. However, analysts expect it to blunt the economic bounce-back when the pandemic restrictions lift. While shortages for many items are annoying, those that really need them are still getting them. Now is probably not a good time to plan your new build, though. **–CL**

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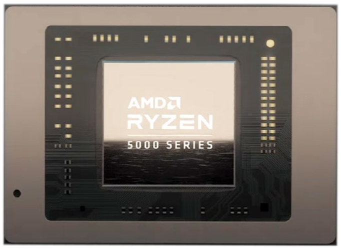

RYZEN 5000 GOES MOBILE

EIGHT-CORE OVERCLOCKABLE MOBILE CHIPS ANYONE?

AMD HAS LAUNCHED THE RYZEN 5000-SERIES mobile chips, and what a tasty bunch they are. In the performance group we have the 45W H series, the 35W HS chips with slighter slower clocks, and the new HX chips, which can be overclocked and are rated at "45W+". All have eight cores, bar two base versions with six cores. Top dog is the Ryzen 9 5980HX with a base clock of 3.3GHz, and a boost of 4.8GHz. All this silicon has Zen 3 cores.

There's also a 15W U range running up to the eight-core Ryzen 7 5800U, with a base clock of 1.9GHz, and a boost of 4.4GHz. At the bottom sits the Ryzen 3 5300U with just four cores. This group includes re-branded 4000-series chips with Zen 2 cores. The graphics are less impressive, with the same Vega units as the Ryzen 4000 series. But early benchmarks put the best new 5000s at top of the mobile gaming tree. **–CL**

AMPERE FOR THE MASSES

New RTX 3060 is fast and affordable

A NEW CARD from Nvidia, the GeForce RTX 3060 sits in the middle of the current Nvidia range, aimed at 1440p gaming. The engine is an Ampere GA106 GPU, which has 3,584 CUDA cores and 112 TMUs, and is coupled to 12GB of GDDR6 memory on a 192-bit interface. The base clock is 1.32GHz, with a maximum boost of 1.78GHz, so it clocks slightly faster than the RTX 3060 Ti. As an Ampere-powered RTX card we get all the fancy ray tracing and DLSS. Performance figures from Nvidia have it comfortably beating the GTX 1060 (and so it should), and manages (roughly) an extra 10fps over the RTX 2060. Nvidia is calling it "the Ampere for every gamer," which means it is actually affordable. Cards are available now (if you can find them) at $329. Initially we just have Nvidia's version, but we'll get a slew of other makers joining the party shortly. Meanwhile, the RTX 3080 Ti has been held back—we have enough unobtainable high-end cards for now. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **FUSION REACTOR WORKS**
South Korea's KSTAR got its experimental fusion plant to run for 20 seconds. It's a start.

✓ **PC SALES BOOM**
The pandemic has helped PC sales; the last quarter of 2020 saw numbers up 26 percent, and last year rose by 13 percent.

✓ **TEXAN FOUNDRY**
Samsung is to build a chip foundry in Texas to make 3nm chips. The plant will cost over $10 billion to build.

TRAGEDIES

✗ **CYBERPUNK 2077**
It sold 13 million copies and reached over 1 million PC players; a month later that crashed to under 200,000.

✗ **GOOGLE'S BALLOONS**
High costs have grounded Project Loon, the idea of using balloons to bring internet access to remote areas.

✗ **CAR MEMORY FAILURE**
Tesla has recalled 159,000 cars with flash memory failures in the Media Control Unit.

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INTEL'S GOOD YEAR

Strong numbers, big plans, and a new boss

INTEL JUST HAD a good year. This may be something of a surprise when we've all been waiting in vain for it to launch killer new desktop chips. Its range is still filled with 14nm designs that use core architectures dating back to 2015—which is ancient when it comes to modern technology. Intel's problems moving to 10nm have been myriad, and 7nm looks like a tough ask.

Yet despite all this the company is in good shape, and has the numbers to prove it. Last year Intel had a revenue of $77.9 billion—eight percent more than 2019. Personal computing earned it just over $40 billion last year. A lot of work has been done behind the scenes to get the processor business back on track, and 10nm chips are finally being made in volume—supply is said to be four times what it was a year ago. Progress with 7nm is said to be "strong," and the target for these is 2023.

Intel also has a new CEO. Bob Swan has gone, and his shoes are being filled by Pat Gelsinger (*pictured above*), who has a background in engineering,—he was part of the team that put the 80486 together. He has some important decisions to make, such as who is going to build Intel's chips. Future Intel designs are to be process-agnostic, something Intel has learned the hard way. This makes it easier to use outside fabricators. Much has been made of the possibilities of using TSMC to fabricate chips. There have been strong rumors that it'll be used to make 5nm Core i3 and i5 chips, then even move to 3nm versions as new production capacity comes online. But Gelsinger may have other ideas: he's hinted that he wants to keep processor production in-house. A process-independent hybrid design using 3D stacking should put Intel right back in the game. **–CL**

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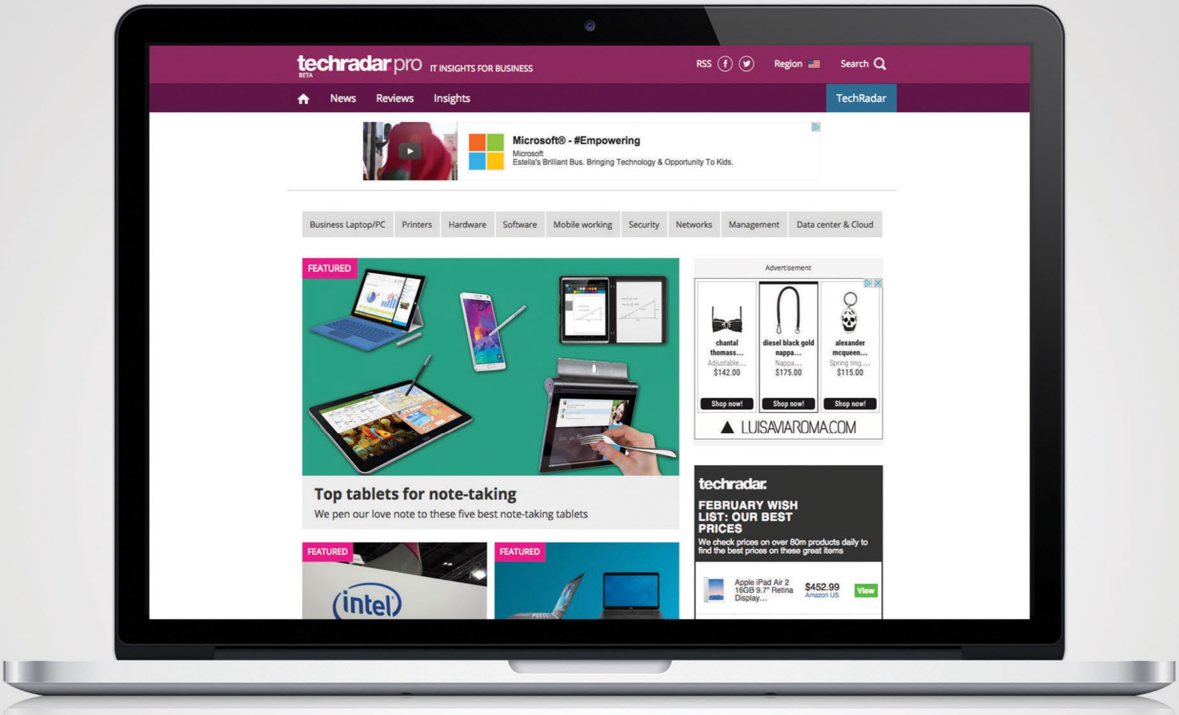

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Atari Lives Again

ARE YOU TIRED of the continual console wars between Microsoft's Xbox and Sony's PlayStation? Well that's what the makers of the Atari VCS hope. It looks as if it belongs in some sort of digital museum. It is meant to be an homage to the original Atari 2600, complete with optional fake wood effect. The development has been slightly tortuous, and required crowdfunding to reach the market. Orders were initially taken in May 2018, and deliveries have just started. No it's not really an Atari—the company died long ago—and the name has been passed around, before being owned by Infogrames (Remember them anybody?), which renamed itself Atari SA.

Inside we find a compact PC running Linux (or Win10 if you must). It's a flexible thing, you could run standard office productivity software between gaming sessions. The streaming apps include HBO, Disney, Netflix, and the usual suspects. More interestingly, it has the Atari Vault, which has over 100 old Atari games ready to play. You also have access to a huge library of other old-school arcade games thanks to Antstream. The magic is powered by an AMD Ryzen R1606G, an embedded processor based on the Ryzen 3 2200U, coupled to either 4GB or 8GB of memory. The graphics are provided by a Radeon Vega 3 chip, and 4GB of VRAM. Storage is 32GB of solid state, and an M.2 slot that can take up to 1TB. We get the usual extras: Wi-Fi, Bluetooth, USB ports. You can use a modern-style controller, or a classic Atari one. Prices start from $199, and run to $399 or more, depending on the edition. **–CL**

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TSMC Invests $25 Billion

The Taiwan Semiconductor Manufacturing Company is one of only two cutting-edge chip foundries. And it's a business that eats capital investments—last year TSMC spent an impressive $17.2 billion, this year it plans to invest between $25 and $28 billion. Most of the capital is aimed at advanced processor deployment and development, as the company expands 5nm production and develops 3nm. A good chunk is being sunk into a new fabrication plant in Arizona. Part of the impetus for such a high investment level may be Intel, which is rumored to use TSMC to make its 5nm Core i3 chips, using a significant slice of TSMC's production capacity. TSMC aims to keep its position at the cutting-edge, and away from less profitable older processes. **–CL**

Consumer Optane Dead

Intel is to stop selling Optane into the "consumer space," so no more high-end Optane drives for enthusiast builders. The move isn't a surprise, as the company recently discontinued almost the entire line of products and announced that it wouldn't be replacing them. Intel is trying to minimize its exposure to the ups and downs of the NAND storage market, and Optane's 3D XPoint memory has limited production capacity. The technology isn't dead, but is now reserved for the server market. The first of the second-gen Optane drives were announced last December, and Intel claims the new PCIe 4.0 P5800X is the world's fastest SSD drive, roughly three times faster than the original Optane. Sounds lovely, but currently there are no plans to get this into any home rigs. **–CL**

GOOGLE VS. AUSTRALIA

It's a bit of a dust-off

GOOGLE IS THREATENING to pull its search engine from Australia. It's a heavy-handed response to a proposed new Australian law, which makes the company responsible for paying royalties to other media companies for the news content it distributes. The proposed law is called the News Media and Digital Platforms Mandatory Bargaining Code, and has been put together by the Australian Competition and Consumer Commission. The law has been introduced in the Australian parliament, with the support of the country's prime minister, who said that legislators would not yield to "threats." This has ramifications across the world, as legislators everywhere will see how far the Australians can get. There are a number of court cases pending here, and the lawyers will be monitoring this one closely. The proposed law has been called unworkable in its current form, principally by Google of course—it points out that it breaks how search engines work, requiring payments for links to news stories and asking for 14 days' notice on changes. Understandably, the company cannot accept these terms.

Could Google actually carry through on its threat? Other search engines are available, but let's be honest, almost everybody uses Google–figures vary depending on the source but cluster around 90 percent, with the rest distributed between half a dozen struggling rivals. It is pretty much an essential service.

The threat to leave is more a negotiating tactic than anything else. Some sort of deal will be made, it's almost inevitable. In France Google was made to negotiate with an association of French publishers, and agreed to pay for any snippets of news stories it shows. The amounts are undisclosed, and no doubt negligible. It has offered to pay Australian news businesses through its Google News Showcase, into which it has invested $1 billion—a lot of money, but not when spread across the entire world's media publishers.

While Australia's attempt to curb Google is doomed, it shows which way the wind is blowing. New media is seen to be feeding on the efforts of old media **–CL**.

Join the conversation!

Discuss all things PC gaming with fellow readers at our official forums

forums.pcgamer.com

PC GAMER

Jarred Walton

TECH TALK

Hello GPU Shortages, Again

LAST YEAR'S DELUGE of graphics card launches felt like a good thing. Ampere brought new levels of performance from Nvidia, and AMD closed the gap—at least in rasterization performance—with its RDNA2 GPUs. Everybody wanted one, and the result was that every GPU launch was accompanied by out-of-stock notifications. Six months on, things aren't much better.

It all started with COVID-19. While the impact on graphics cards might seem like a relatively small item in the grand scheme of things, the manufacturing plants that produce graphics cards—from the GPUs themselves to the memory chips, VRMs, capacitors, PCBs, and other components—were all affected to varying degrees. The problem is that our manufacturing supply chain doesn't deal well with delays, and it can take days if not weeks when restarting production lines to get everything running smoothly again.

Compound all of that with shipping delays. Across the globe, a large chunk of the shipping industry has been diverted to help with routing medical supplies, and now vaccines. So an industry already starved of supplies also now faces restricted shipping.

Finally, we have the unprecedented demand for PC upgrades. Perhaps we should have seen this coming, but early in 2020 companies couldn't accurately forecast demand for their products. Billions were facing government-enforced lockdowns, millions lost jobs, schools were closed. The assumption at the time was that demand would drop. Instead, people working from home wanted better PCs, and many figured that escaping into their favorite games would be a good way to pass the time.

Compounding interest is a harsh mistress, and if all of the above wasn't bad enough, now we have the surging popularity (again) of cryptocurrencies like Bitcoin and Ethereum. December and January saw all-time highs for BTC and ETH, and many other crypto coins as well. Which means, on top of everything else, we're once again looking at miners trying to snap up cards for their own use. It's an extremely volatile institution, but in December and January, earning around $8 per day from an RTX 3080 mining Ethereum was possible.

Bots and scalpers further exacerbate the situation, and on top of that the exception on graphics card import tariffs expired, so now cards shipped from China are subject to an extra 25-percent tax. There are perhaps ways around that (like assembling a card in Taiwan), but we've received updated pricing data from multiple vendors.

How do AMD and Nvidia fix the problem? In a word: time. Wafer orders for GPUs placed with Samsung and TSMC typically take several months before the GPUs are ready for integration into graphics cards, and they're only one part of the product. Getting all the other components together and assembling them into the final parts takes time as well, and the general rule is that it takes around six months for a chip to go from a wafer start to retail graphics card sitting on a shelf. And that's the easy part.

The bigger problem now is capacity. The increased demand for computer parts and other technology devices has basically tapped out all of the state-of-the-art manufacturing facilities. TSMC can only do around 60,000 wafer starts per month without building more fabs, but building a fab is a multi-billion-dollar project that takes several years. The same goes for Samsung or any other company looking to add capacity.

Last year, the word from Nvidia was that increased supply of Ampere GPUs would start in February. More recently, Nvidia's CFO indicated that it could take several more months before supply starts to catch up to demand. AMD hasn't made any promises, but its prospects don't look any better. My extremely cloudy crystal ball suggests that this summer could perhaps be when last year's GPUs actually start sitting on shelves for more than a second.

RTX 3080
RTX 3090
RADEON

Our collection of unicorn graphics cards: the RTX 30 series and RX 6000 series remain at near-mythical levels of availability.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

DOCTOR

THIS MONTH THE DOCTOR TACKLES…

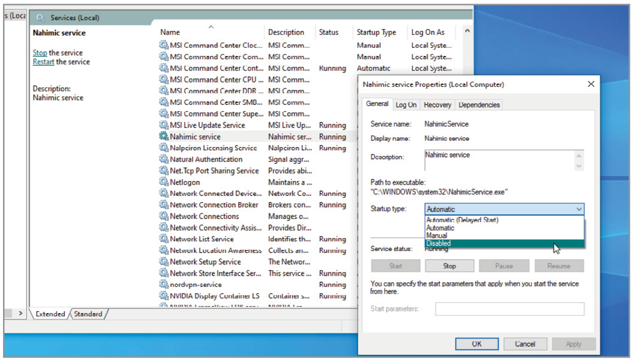
> Sound Driver Lag
> Power Problem
> Driver Updates

Update Windows Media

In the Holiday issue on virtual machines, it mentioned that we can get images for old Windows boot disks at www.allbootdisks.com—do these images contain the original Windows version, or do they include all the updates to these older versions that were supplied before MSFT support ended? It wasn't clear in the article. **–Phil West**

THE DOCTOR RESPONDS: These boot disk images aren't suitable for installing Windows—they basically provide boot and repair functions only. If you read the article again, you'll see that Neil has directed you to the website to obtain a boot floppy disk image for Windows 95, because the Windows 95 CD-ROM itself wasn't bootable, and requires this to run.

When it comes to updating older machines, you'll find that most updates and patches are available online. In the case of Windows 95, you'll find key patches at http://bit.ly/MPCWIN, while Windows XP users can still manually download all updates—including Service Pack 3—from Microsoft's own catalog (go to www.catalog.update.microsoft.com and search for "XP SP3"). If you're creating a Windows XP virtual machine, once it's up and running you can create your own install media with SP3 and all post-SP3 updates slipstreamed into it using nLite (www.nliteos.com). This must be run inside your virtual XP machine, and the ISO file generated, then copied to a safe location on your main machine for future use.



Nahimic service

Stop the service
Restart the service

Description:
Nahimic service

Name	Description	Status	Startup Type	Log On As
MSI Command Center Cloc...	MSI Comm...		Manual	Local Syste...
MSI Command Center Com...	MSI Comm...		Manual	Local Syste...
MSI Command Center Cont...	MSI Comm...	Running	Automatic	Local Syste...
MSI Command Center CPU ...	MSI Comm...			
MSI Command Center DDR ...	MSI Comm...			
MSI Command Center SMB...	MSI Comm...			
MSI Command Center Supe...	MSI Comm...			
MSI Live Update Service	MSI Live Up...	Running		
Nahimic service	Nahimic ser...	Running		
Nalpciron Licensing Service	Nalpciron Li...	Running		
Natural Authentication	Signal aggr...			
Net.Tcp Port Sharing Service	Provides abi...			
Netlogon	Maintains a ...			
Network Connected Device...	Network Co...	Running		
Network Connection Broker	Brokers con...	Running		
Network Connections	Manages o...			
Network Connectivity Assis...	Provides Dir...			
Network List Service	Identifies th...	Running		
Network Location Awareness	Collects an...	Running		
Network Setup Service	The Networ...			
Network Store Interface Ser...	This service ...	Running		
nordvpn-service		Running		
NVIDIA Display Container LS	Container s...	Running		

Nahimic service Properties (Local Computer)

General | Log On | Recovery | Dependencies

Service name: NahimicService
Display name: Nahimic service
Description: Nahimic service
Path to executable:
"C:\WINDOWS\system32\NahimicService.exe"
Startup type: Automatic
Automatic (Delayed Start)
Automatic
Manual
Disabled
Service status: Running

You can specify the start parameters that apply when you start the service from here.

Start parameters:

Try disabling Nahimic if you have problems after a sound update.

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Sound Driver Lag

I recently updated the BIOS in my ASUS ROG Maximus XI PC and then updated the Realtek Audio driver from 6.0.1.8557 to 6.0.1.8960. Everything appeared normal, but when I then tried to open a browser window, there was an 8-10 second delay before the window opened. No such problem in other apps. Reverting to the old driver had no effect—I had to run System Restore to revert my PC to before I installed the driver update. I tried again, but after uninstalling the original driver, I can't install any other driver—old or new—without the lag returning. Can you help me pin down what's causing the browser lag? I contacted ASUS but they weren't ANY help. **–Richard King**

THE DOCTOR RESPONDS: You're not the only one to complain about a 10-second lag affecting all browsers, and at least one person has traced this problem to the Nahimic service, which is installed alongside the Realtek drivers. Nahimic is linked to the sound enhancements used by many motherboards (specifically ASUS and MSI) and companion software such as Sonic Studio III, which is installed alongside the drivers.

Start by reinstalling the latest driver, rebooting, and then attempting to disable the Nahimic service—open Task Manager to the Services tab, right-click "NahimicService," and select "Stop." Now open your browsers to see if the problem is eliminated. If it is, then you've identified the cause of your problem. For a more permanent fix, right-click "NahimicService" again, but this time choose "Open services." Right-click its entry in the Services panel and choose "Properties," then click "Startup type" and change it to "Disable." Click "Apply → OK" and reboot your PC—this should eliminate the problem once and for all.

Prioritizing Driver Updates

I would like to know which driver updates are most important, and which ones can slide. I use the free version of Driver Max that only allows me to download two updates a day. After the scan there's always a lot of drivers that are very cryptic. I do the chipset, video, LAN, and sound updates, which leaves things

↘ submit your questions to: doctor@maximumpc.com like buses and others that I don't understand. My question is, what is important, and what can be left alone? **–Jim Piche**

THE DOCTOR RESPONDS: It's an impossible question to answer, Jim, because while it's advantageous to have the latest versions of some drivers—your graphics being the most notable case in point—with others it depends on whether the driver update fixes a major problem, improves performance, or adds new features. Indeed, in some cases, such as with sound cards, it's often a case of "If it ain't broke, don't fix it!"

That said, your main issue is relying on Driver Max to keep your drivers up to date. Any app that limits you to just two updates per day isn't worth persevering with—either bite the bullet and purchase a lifetime license ($29.80 at time of writing) or look for another approach. The obvious alternative is Snappy Driver Installer, which is free, portable and open source. Download and run the Lite version from https://sdi-tool.org/—it's a little less user-friendly than other driver tools, but it's a good non-restricted alternative.

Most people's needs can be met by the update tool supplied by their PC or mobo manufacturer, which covers all the core drivers, such as chipset, SATA/RAID and onboard graphics, sound, and network drivers. Check the support section of your manufacturer's website for details—such as Live Update from MSI and ASUS, or HP Support Assistant. Pair it with the official AMD or Nvidia graphics drivers, which automatically alert you to updates, and you'll be covered.

PC Switches On And Off randomly

Doc, I feel my sanity fraying. My HTPC has started powering on (and off) randomly. I've ruled out the PSU with three different tries. I've flashed my BIOS. I'm fairly confident I don't have a short anywhere. Is my Z87M-plus motherboard just going bad? **–James Breen**

THE DOCTOR RESPONDS: There are a few more tests to perform. First, check the various cables connecting bits and pieces to your PC. If these appear to be undamaged and securely plugged in—or the problem persists after you've swapped them—then you'll have to bite the bullet and strip your PC down to its bare bones (don't forget to earth yourself first). This involves unplugging everything from the motherboard, including components, cables and —yes—the CPU fan and heatsink, and CPU itself. Next, remove the mobo from your case. Carefully clean off any dirt or grime you come across using a can of compressed air for loose debris, and a cotton swab and rubbing alcohol (you'll find plenty of advice online) to ensure all connections are clean. Make sure the motherboard is left to dry completely.

Check your case carefully to ensure there are no loose screws that may have been responsible for any shorts, then refit the motherboard carefully before plugging in all removed components and cables, checking each one for possible signs of wear and tear. Finally, power the PC back on to see whether it's made any difference. If the problem remains, then it may be time to look at replacing it.

No 4K Encoding?

When attempting to convert (encode) a 3,840 x 2,160 video using Wondershare UniConverter on my Dell XPS 15-inch 9500 'Creator Edition' laptop, Task Manager shows the encode process immediately switch from my Nvidia GeForce GTX 1650 Ti GPU to the integrated Intel UHD GPU. It seems the GTX 1650 Ti is only capable of converting video up to 1,920 x 1,080 with Nvidia GPU acceleration enabled. Anything higher—including 2,704 x 1,520—defaults to the slower Intel UHD GPU, where encode times are tripled. Wondershare states it's a hardware limitation of the GeForce GTX 1650 Ti, but why? I can find no definitive answer via Dell or Nvidia's online communities.

I've tried disabling the Intel UHD graphics driver with Device Manager to try and force priority onto the FTX 1650 Ti. System stability is compromised, and it has no impact on Nvidia GPU acceleration. Why is the GeForce GTX 1650 Ti not capable of converting video resolutions above 1,920 x 1,080? If it's a hardware limitation, why did Dell offer a 4K-limited GPU on a premium system that promotes 4K creativity? **–Derek R**

THE DOCTOR RESPONDS: There's no hardware limitation we know of preventing you from using Nvidia's NVENC encoder to rip 4K video with a GeForce 1650 Ti chip—have you tried a different software package? For example, HandBrake (www.handbrake.fr) supports NVENC-accelerated encoding, and the Doc has successfully converted 4K video using its NVENC codec with a GTX 1660 SUPER.

There are, however, good reasons why you might prefer to put up with the slower CPU-based encoder. First, the NVENC encoder is optimized primarily for real-time streaming, which basically means it uses higher bit-rates to produce video of comparable quality to the CPU encoder, which translates to significantly larger file sizes—more than twice the size in your case thanks to the GTX 1650 Ti's older Volta architecture. There may also be visibly inferior image quality. However, if space isn't an issue but encoding times are, then give HandBrake a try using its Production Max or Production Standard presets if you're looking to convert to 4K.

AMD USB Follow-up

Thank you for your response to my query regarding my USB issues on my ASUS X570 ROG Crosshair Hero VIII (July 2020 issue). I wanted to follow up and let you know my findings.

Unfortunately, none of your suggestions worked, and I ended up buying a new motherboard of the same model. Surprisingly, the new motherboard exhibited the same issues, which meant it was not the motherboard.

After much trial and error, it turned out that my Corsair Commander Pro module that controlled the RGB lighting and case/AIO fans on my Corsair was the culprit. The Corsair H115 RGB Platinum AIO is plugged into one of two USB ports in the Pro, which was defective. If I plugged the AIO into the second USB port, the errors vanished.

Secondly, I also purchased the Phantaks RGB NEON light strips, which are supposed to work with Corsair's iCue app. While the app recognized the light strips, it couldn't control the RGB color effects. To get it to work, I had to disable the ASUS plug-in from iCue and install ASUS Aura Sync, which controlled the light strips with no issue. I should note that you can't use ASUS's Armory Crate as it conflicts with iCue, which loses the AIO cooler in the app. Again, thank you for your support. **–Jon Shimamoto**

THE DOCTOR RESPONDS: Thanks for following up with us, and for sharing your eventual fix, as well as tips for handling various lighting setups. It just goes to show that trial and error is often the only way to truly get a handle on a problem—glad you've finally got it sorted. ⏻

LED
FANS
USB
TEMP

A defective USB port in the Corsair Commander Pro caused havoc on Jon's PC.

© CORSAIR

TALKING

BY **IAN EVENDEN**

Taking the Fight to the Millennium Bug

We sat down with a retired IT engineer to discover what it was like to face the Y2K bug

We've decided to take a step back and look at perhaps the computing world's most complex technological predicament—the Y2K bug. You can read all about that on page 32, but we wanted to take it further, and interview a man who was on the ground through it all.

Richard Hassett was an engineer and programmer, working in the IT departments of big business at the turn of the millennium.

Richard Hassett was working with large and mid-range IBM machines in the run-up to the millennium that were interacted with through a network of dumb terminals. As part of the enormous effort required to "fix" the Y2K problem, he spent a lot of time making sure they were ready for the transition.

MPC: Hi Richard. We know what happened in theory, with integer overflows making life hard for any computations that relied on dates, but what was your experience of Y2K?

Richard Hassett: I only became aware of it a few years before the millennium, but it goes back a bit beyond that. We were told in the 70s that a program you write today will last about eight years or so. As it happened, it didn't work out that way because basically, you'd take a program, update it, and keep a lot of the old code in there, but some became redundant... That's why old programs were still being used when we got to 2000.

You could do all sorts of mathematics with dates. If you had a date which is normally stored "year, year, month, month, day, day," you could subtract one from another if you want to check if something's older than something else, or if you want to sort a list into order. Now that's fine until you get to 1999, but it will have a problem when you get to the year 00, which is 2000. It's lower than the older year. So instead of subtracting 97 from 99. You're subtracting 97 from 0.

If you're talking about shares, then perhaps you want to know what the share price was on a given date. And if all of a sudden it's not in sequence, it's going to look a bit odd. That's what the problem was. So basically we had to go through all the program code to make sure we were storing it with four digits for the year instead of two.

On IBM mainframes a record on a file is a string of data. Each individual program states where on the record each field starts, and for how many characters and decimal places, if numeric. If you change the year data from two to four bytes then all the fields that follow have to be changed, adding two bytes for each changed date field. This is compounded by overlapping fields—you may only want the YY data but you may also want a field to contain YYMMDD. Because you can select data in this way, you could store the dates in other formats such as DDMMYY, which I have seen.

I was working on an AS/400 iSeries computer, which uses a database where each field on a file is described and named individually when the database is created. It can therefore be changed at any time, and the changes will be reflected in the program. This makes it much easier to change not only the code, but also the data in the file. You only have to change the fields containing the year.

MPC: There's so much that depends on dates, then?

RH: Yeah, anything that needs sequencing, or if you need to do something once a week or once a month, then you can work that out by the date... Once you get to the stage where you can't subtract one from the other to find out, you're in trouble.

MPC: So when it came to actually working out all the kinks and the bugs with Y2K, what type of machines did you find yourself working on?

RH: I was working on the IBM AS/400 mainly. That had two predecessors, System 36 and System 38, which were merged together. And then it became the iSeries. There are lots of variations of it. It came out in 1988, and later there were different versions of the machine, with IBM RS64 CPUs.

Small to medium companies could run on one. Places like American Express and Cable and Wireless had several. It was called a mid-range. It wasn't a mainframe, but it wasn't a PC. It was in between, but towards the end they just got so big that they were almost mainframes.

It sat in a room somewhere, and people accessed it through dumb EBCDIC terminals—which weren't like ASCII terminals, they were much chunkier and heavier—or PCs that had an emulator of the access software on them as an application. PCs were about $5,000 in the early 80s. And we were using a $5,000 PC to emulate a $1,000 terminal. But of course that was only one of its functions.

MPC: Okay, that's a new one for us. So what even is EBCDIC exactly?

RH: EBCDIC—I can't remember what it stands for now, I don't know if I ever knew! [Extended Binary Coded Decimal Interchange Code, an eight-bit character-encoding system descended from the punch-card codes of the 1950s, now superseded by Unicode like ASCII.] It was like IBM's version of ASCII, which is what we were using on the PCs.

It was very robust. The network was a thing called a token ring. We didn't have the Ethernet networks then. It used twinaxial cables, like coaxial but with two lines going down it. And basically, instead of broadcasting to everyone on the network, and the machine that wanted the data would pick it up, it sent it around the network. There was a token going round that had an address on it, and it dropped it off where it was required.

MPC: Sounds... slow and complex. So in order to update one of those machines to be Y2K compliant, what exactly did that entail, and how did you go about doing it?

RH: You had the programming language, which was on that particular machine. I think some were COBOL, but most were RPG III. It stood for Report Program Generator, and I worked on RPG II and III.

It was a lovely language, it actually was really good. I enjoyed working with that one. [This was IBM's high-level language dating from 1959. Its latest version, RPG IV, was last updated in October 2020.] It was literally a case of getting the source code from all the programs you wanted to run on the thing, and going through each one individually, finding any code that involved dates and changing it, then testing it, making sure it works. This is what people these days don't do—they just put it live, wait for the customer to find it and then call them up and say there's a problem with their program.

A small AS/400 model, IBM's mid-range computer aimed at small businesses. Essentially a high-end server, applications ran on its processors and were sent out to terminals.

An IBM 3279 block mode terminal, featuring a console-style keyboard. This was IBM's first color terminal, introduced in 1979.

Well, you know, when I was programming and that happened, the programmer would have his balls broken chronically by his workmates. But now that seems to be the way to do it.

MPC: We couldn't possibly comment on that. Were you changing the programs to support a four-digit date code? Or were you saving time by windowing, and just kicking the can further down the road?

RH: Some people did that, and I said, "Well, hang about, we gotta future-proof this." It just seems ridiculous to me, so I didn't do it, because I was a programming manager at the time, so you know, my stuff is the way that we decided was the best way to do it—[we] future-proofed it.

I think it all goes back to this idea that programs don't last more than eight years, but I expect some of those AS/400s might still be running. I gave this all up in 2007, but they may still be making them as the iSeries, unless they've changed the name again. [They're called Power Systems these days, with 4GHz, 14nm Power 9 processors with 12 or 24 cores since 2017. The cores are up to eight-way multithreaded.]

There's not so much RPG code these days, it's all that awful Unix, which was never nearly as good. The thing is, they said it's got to be more accessible to people, and things were getting easier with computing. Then the universities got hold of it, and with these university boys, if it's not complicated, then it's not worth doing. So it started getting really complex.

Unix is an absolutely dreadful operating system, but... people grew up using it, and that's how it got into the business world.

Computing changed a lot once the PC came along. Standards fell a lot. People wanted stuff cheap so they got it cheap. Before, computing had been very expensive, so the PC made it cheaper, but the software was expensive because it was done by people and it was tested thoroughly. Well, they don't do that anymore, because they can't afford to. They'd rather put something out there that doesn't work than have it working and not out there.

MPC: That's certainly an interesting perspective, thank you very much for your time.

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THE ULTIMATE 4K GAMING RIG

Zak Storey attempts to capture that great white whale of PC gaming

IT'S THAT ALMOST MYTHICAL THING—as gentle as a whisper, and just as fragile. We move one step closer each and every year, and yet it seemingly moves one step further away every time we approach it.

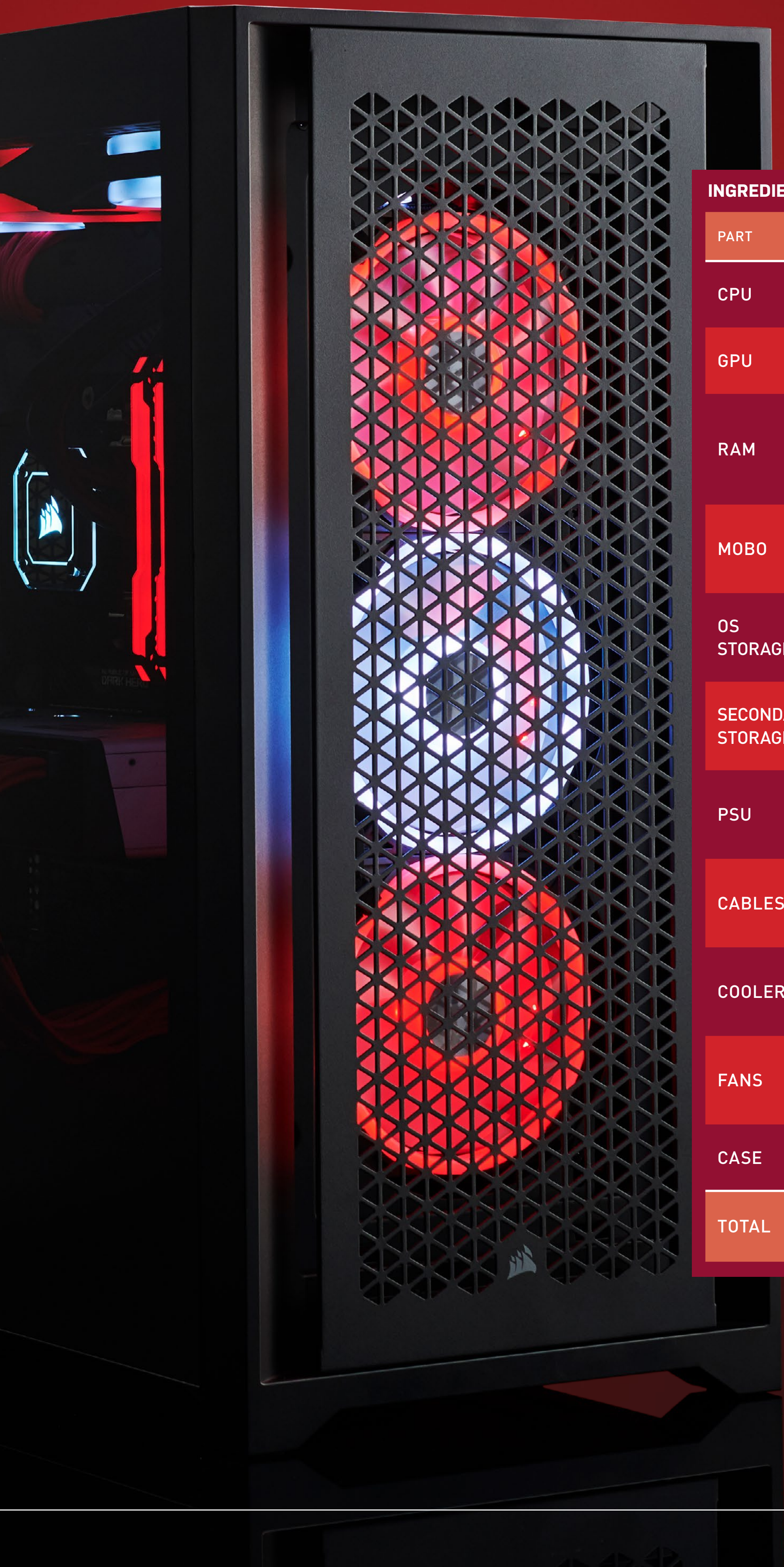
4K gaming is something we've written about for many years at *Maximum PC*, and something that has never come to fruition—at least, not in the way we want it to. Why is that? Well, just as much as technology advances, processors get more efficient, and graphics cards render an ever greater number of frames, so to do graphics improve, code gets denser, and more modern effects come into play to imitate real life, requiring more processing power.

If the question was "Are the games of 2016 playable at 4K today at 60fps?" we could happily say "Yeah, with ease"—and yet that's not the aim. We are human, and because of that, we constantly strive for more. It's in our very nature and is the driving force in our society.

This hunt for gaming excellence leads to better technologies that worm their way into every facet of our existence: better graphics cards, more powerful processors, and faster memory and storage affect everything from video rendering and 3D modelling to tailored medicine, protein folding, and more. Without this multi-billion dollar industry we would undoubtedly be worse off as a species.

And so, we're once again hunting for that mythical white whale. The aim is simple: 4K gaming at frame rates that are as high as we can muster, on a budget that is far more reasonable than it was in the past. Is this the moment we finally see 4K overtake HD and QHD as our main resolution? Let's find out.

BUILD IT PG. 26 ➡



INGREDIENTS

PART		RETAIL PRICE	STREET PRICE
CPU	AMD Ryzen 9 5950X	$800	$1,200
GPU	AMD Radeon RX 6800 XT 16GB	$650	$1,491
RAM	64GB (4x8GB) Corsair Vengeance RGB Pro @ 3200 CL16	$290	$739
MOBO	Asus ROG Crosshair VIII Dark Hero	$420	$740
OS STORAGE	1TB Corsair Force MP600 M.2 PCIe 4.0	$190	$185
SECONDARY STORAGE	2TB Corsair MP400 M.2 PCIe 3.0 SSD	$288	$255
PSU	750W Corsair CXF750 80+ Bronze	$110	$110
CABLES	Corsair Pro PSU Cable Kit Type 4 Gen 4 - Red	$110	$110
COOLER	Corsair iCUE H150i Elite Capellix AIO	$190	$190
FANS	2x Corsair iCUE QL120 Fans 3-Pack	$260	$366
CASE	Corsair 5000D Airflow	$150	$150
TOTAL		$3,458	$5,536

PRICES CORRECT AT THE TIME OF PRINTING

CPU $800 RRP / $1,200 Street Price

• AMD RYZEN 9 5950X

Right now this is the king of all processors. AMD has dominated the field with its Ryzen 5000-series chips, and at the top of the stack is the Ryzen 9 5950X. Coming in at a respectable RRP of $800, this thing packs 16 cores, 32 threads, and a max clock speed of 4.9GHz, with DDR4 support up to 3,200 MHz (although 3,600/3,733 still remains the best for maximum core complex performance).

Along with its recalibrated 64MB of shared L3 cache and 8MB of L2 cache, this 7nm behemoth packs some of the best single-core performance in the business, achieving a massive 652 points in Cinebench R20's single-core test. Compare that to Intel's best, the Core i9-10900K, at 533, and it's 22-percent faster. The only things faster than it in multi-core scenarios are Ryzen Threadripper 3960Xs and above. It's an insane amount of performance for a consumer desktop part—at least if you can find one in stock, and not at that ridiculous 50-percent markup we're seeing today.

AMD Ryzen 9 5950X
AMD
RYZEN

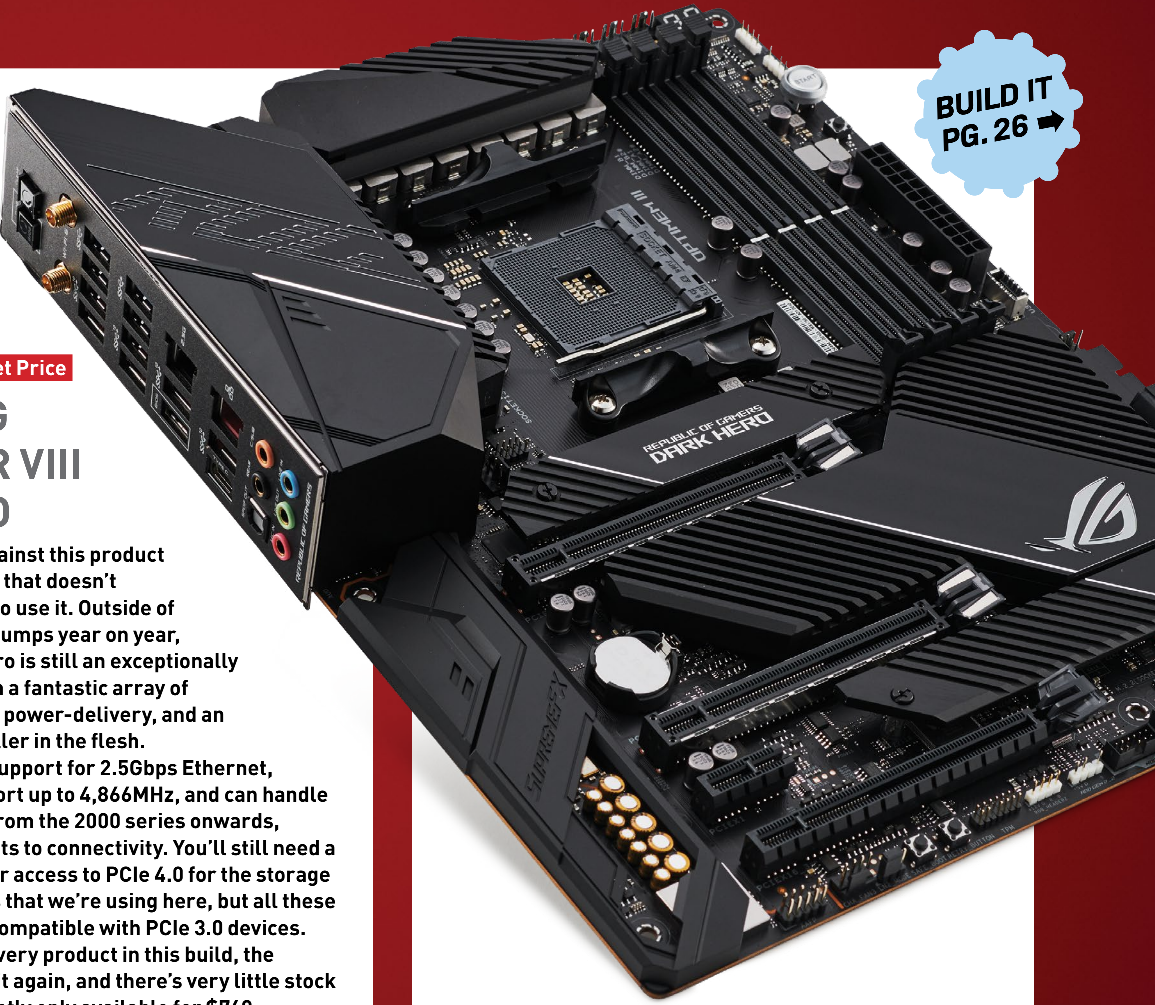
GPU $649 RRP / $1,491 Street Price

• AMD RADEON RX 6800 XT 16GB

The new kid on the block, AMD's Radeon RX 6800 XT may not quite be at the top of the Red GPU stack compared to our CPU of choice, but it's darn close, and comes packing 72 of AMD's latest RDNA2 compute units, 4,608 stream processors, and a grand total of 26.8 billion transistors. On top of that it boosts up to an impressive 2,250MHz at max load. That's not too shabby. Pair that with 16GB of GDDR6 on a 256-bit bus, and we're onto a scorching-hot card that's hopefully more than capable of powering all of the latest titles at 4K 60fps, if not much higher.

The downsides? Well it's a power-eater for sure, with a rated TDP of 300W. The cooler design itself features some red accents, so it can be difficult to color-coordinate your system. Oh, and it's not in stock anywhere, really. And if it is, it's 129 percent its original price thanks to scalpers.

RADEON
RADEON



BUILD IT
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MOTHERBOARD
$420 RRP / $740 Street Price

• ASUS ROG CROSSHAIR VIII DARK HERO

We may have railed against this product only an issue back, but that doesn't mean we're not going to use it. Outside of those increased price jumps year on year, the Asus ROG Dark Hero is still an exceptionally impressive board, with a fantastic array of connectivity, excellent power-delivery, and an aesthetic that looks killer in the flesh.

It also comes with support for 2.5Gbps Ethernet, Wi-Fi 6, memory support up to 4,866MHz, and can handle any Ryzen processor from the 2000 series onwards, albeit with some caveats to connectivity. You'll still need a third-gen and above for access to PCIe 4.0 for the storage and graphics solutions that we're using here, but all these ports are backwards compatible with PCIe 3.0 devices.

Sadly, like almost every product in this build, the scalpers have been at it again, and there's very little stock online, so this is currently only available for $740.

RAM **$290 RRP / $739 Street Price**

• 64GB (4X8GB) CORSAIR VENGEANCE RGB PRO @ 3200 CL16

If you've had a cursory glance at the cover and this feature's opening spread, you'll notice that this thing is illuminated to the hilt with RGB lighting. We're leaning on Corsair a heck of a lot to get this build all black, white, and red—those traditional PC gaming colors.

To that end, we've also borrowed some of the memory from one of our older builds, the Data Scientist rig. We've grabbed 64GB of the stuff straight from the computational powerhouse, as it comes complete with a 3,200MHz frequency, and a C16 latency rating, making it ideal for our 4K gaming aspirations. There's certainly no chance we'll be throttling on memory here, that's for sure. We're not too worried about it not hitting that 3,600/3,733MHz sweet spot—in our testing, performance gains on that front tended to be within the 1-3 percent margin, and not worth the extra cash on an already expensive product due to stock shortages.

OS Storage $190 RRP / $185 Street Price

• 1TB CORSAIR FORCE MP600 M.2 PCIE 4.0 SSD

We can't build a kick-ass 4K gaming PC without upping the ante when it comes to storage. Across our system we're taking advantage of M.2 PCIe devices, with one of our most used drives at this point, the Corsair Force MP600 M.2 PCIe 4.0 SSD. Utilizing the Phison E16 controller, this thing tops out at 4,950MB/s sequential read, and 4,250MB/s sequential write. It also features a five-year warranty, support for AES 256-bit encryption, and an impressive 1,800 TBW (terabytes written) endurance rating.

It's also worth noting that the latest Corsair Force MP600 Pro has just been announced at the time of writing. So if you can, pick up one of those instead, as it ups those sequential figures all the way to 7,000MB/s for both read and write speeds. Is that necessary for gaming? Probably not, but it's the only product on our list that hasn't been hit by mass shortages and price scalping, and if you fancy working on any non-gaming projects, then a nippy OS drive will help.

Secondary Storage $288 RRP / $255 Street Price

• 2TB CORSAIR MP400 M.2 PCIE 3.0 SSD

Our drive of choice for our secondary storage is the Corsair MP400. This is what QLC drives should have been to begin with. Although it's not as rapid as some of its SLC brethren, Corsair's MP400 packs in an impressive warranty, alongside solid sequential performance for small file transfers, making it ideal for game and media storage. This is in part due to its large dynamic write cache, and it'll happily top out at 3,480MB/s sequential read, and 1,880MB/s for a good 250GBs before falling off that cache cliff in the writes. Considering that a lot of the data you'll be moving is a lot smaller than that, you shouldn't run into trouble.

The cache does recover somewhat quickly (our reviewer tells us, usually within 30-40 minutes), but let's be fair, this is a 2TB drive for just over $250. That's around 8GB per dollar, making it one of the best-value SSDs on the market right now, and thankfully not a product that's massively out of stock anywhere.

PSU & CABLES $220 RRP / $220 Street Price

• 750W CORSAIR CXF750 80+ BRONZE & CORSAIR PRO PSU • CABLE KIT TYPE 4 GEN 4 – RED

We're keeping things simple with our power supply setup. It's an 80+ Bronze, 750W affair. That should be more than enough for our system—we expect at max load this thing will draw about 600W from the wall, at least according to PC Part Picker. It's worth mentioning in regards to those figures that these are worst-case synthetic scenarios. It's highly unlikely you'll be in a situation where both the CPU and the GPU are at max load simultaneously, as one will inevitably bottleneck the other. As such, even 600W is pushing it really. However, it is right on that sweet-spot for 80-percent efficiency.

The CXF comes with an RGB fan as standard, and we've paired it with a set of Corsair's Red Pro cables to make that Radeon GPU pop.

CORSAIR
QL120 RGB
Lighting Node CORE
SUPER CHILLED
iCUE

COOLING $450 RRP / $556 Street Price

• CORSAIR ICUE H150I ELITE CAPELLIX AIO & 6X • CORSAIR ICUE QL120 FANS

For cooling, we're again leaning on that big Californian giant in the form of the H150i Elite Capellix cooler. Generally speaking you can get away with a 240mm AIO for the Ryzen 9 5950X, but we want to make sure we've got enough headroom to play with if we decide to go down the overclocking route in the future. We might need to keep an eye on the PSU if that's the case. We're also big fans of Capellix LEDs, so the H150i Elite is a no brainer, although it is a rather expensive cooling combo.

We've also got two sets of Corsair QL120 triple-fan packs. These each come with an RGB commander module to connect six of them together and control them via iCUE.

CASE $150 RRP / $150 Street Price

• CORSAIR 5000D AIRFLOW

And last but by no means least, we have our chassis of choice for this build, the Corsair 5000D Airflow. The bigger brother of our budget favorite, the 4000D Airflow, the 5000D expands on those newly introduced design decisions found in this latest generation, and comes with a ton of hardware support, including E-ATX mobos, vertical GPUs, push-pull rad configurations, and side-mounted radiators. On top of that, it also features those small touches to the aesthetic design that the 4000D has as well.

What's more impressive is the price—at $150 it's nothing short of awesome, and follows a very similar vein to the 4000D. It also has its spin-off variants, including a solid-panel version (the 5000D), an RGB glass variant (5000X), and of course is available in black or white as well. You can read our full thoughts on this one on page 82.

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THE LUCID DREAM

MYTHICAL, BEAUTIFUL, LUMINOUS. TAKE A LOOK AT OUR CASTLE IN THE SKY

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY TO MEDIUM**

IN JARRED'S TECH TALK this issue (see page 15), he went into great detail about the shortages we're seeing in the industry right now. Thanks to a multitude of different factors, the world of computing is fragmented in terms of stock, and it's only snowballing further. There's a massive disconnect between the RRP and the actual price you can buy these components for now, and it's all due to demand far outstripping supply, with some unscrupulous agents in the middle to boot.

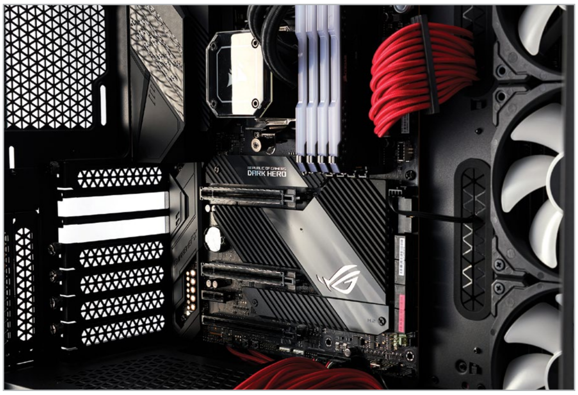
We live in unprecedented times, and in a world so connected to its technology, especially for enthusiasts, professionals, and hobbyists like ourselves, we're suffering because of it. That's why for the first time, we've included two price lists in our ingredients table at the beginning of the feature—one for the actual RRP that these things should be selling for, and the other to indicate the current street price you could theoretically buy the parts for today.

Now let's just start by saying this: do not buy this today at its current price. Encouraging scalpers only leads to more of it happening in the future, further driving up costs for us all and putting what are meant to be affordable parts way out of reach of the everyday enthusiast. What we're looking at here is an example of what can be built and achieved when stock finally comes back into existence again—something that should hopefully occur by this summer.

This build's also a bit of a special one for us, for a number of reasons. First up, it was actually meant to be in the last issue of *Maximum PC*. The reason why it wasn't was because this editor came down with COVID, and Christian is also out due to health concerns. You'll also notice that there's a ton of Corsair stuff in the build too. Corsair sent us the 5000D Airflow long before the NDA was due to lift. In fact, the whole idea was that we'd have this kick-ass AMD build ready, color-coordinated, and illuminated in the mag, right on time for the case's NDA to drop. If you work in print media, let us assure you, meeting an NDA is like gold-dust, and something we almost always pursue. Obviously, that didn't quite go to plan, but that's not stopping us from putting this epic build together for this issue.

This time around, again due to that pesky pandemic, we're going to show you some of our favorite highlights from this system, what considerations we made, and how we put the whole thing together. It's a bit more unorthodox than our usual builds, but sadly COVID restrictions are also having an effect in our workplace, and we're no longer allowed in the same room as our tech-savvy photographer while we actually do the build.

So let's go through this 4K gaming build, take a look at this awesome system, and explain how we forged every element of it.



1 DOING THINGS DIFFERENTLY

CORSAIR'S 5000D AIRFLOW is a behemoth. It's not quite full-tower level, but it's much larger than the 4000D mid-tower case. This is in part thanks to its ridiculous amount of compatibility for cooling components. Inside you'll find a cable-tidy bar, cable grommets, full-length PSU cover, vertical PCIe mounts, push-pull support in the roof, plenty of ventilation, and cable-management features in the rear. There's even support for side-mounted radiators.

We removed the front panel, the roof, the two dust filters, and the cable-tidy bar. We knew we were going to be installing fans on the side of the chassis (because, well, it looks cool). The cable bar is attached via four Phillips-head screws in the back of the chassis. We pulled out the 3.5-inch hard drive cage as well, to give us extra room to mount the power supply and tidy up the cables.

Motherboard installation went swimmingly. We installed four sticks of our DDR4 here, routed the cable kit in, and installed our AIO, a painless procedure with AMD as it doesn't require a special backplate.

2 AIO & MEMORY WOES

THERE'S NOTHING BETTER out there right now for brightness than a Capellix LED. On the pump block itself, you can change the color of this to white, instead of black. Effectively, the top is a clear block with the Corsair logo engraved onto it, and the part below is a translucent acrylic. Theoretically you can remove the lot, and 3D-print your own cover if you want. One thing that did annoy us, however, is the fact that there's no easy way of routing the pump cables from the motherboard block out the top of the case. Usually we tuck these out of the way, or under a heatsink, but there's just nowhere to hide it.

At this point in time, we've had to drop down to two memory sticks to get it to boot. This gives us 32GB total DDR4 at 3,200MHz, instead of the 64GB we wanted. Effectively the motherboard wouldn't cycle, and we just ended up with a light informing us of a DRAM error and a blank screen. Remove two sticks, no problem. Place them back in, problem. This is likely due to an early BIOS on the Dark Hero having issue with our high-density memory from Corsair and Ryzen 5000 chips, and we're still trying to get to the bottom of it.

3 M.2 SLOT #1

INSTALLING AN M.2 DRIVE is, at this point, easier than installing a 2.5-inch SSD in our eyes. There's fewer cables, less fuss, and it looks a lot cleaner—and that's before you consider the performance gains you get from it. At this point you can get standard SSDs as M.2 drives as well, but honestly, we're not even sure that it's worth doing these days. After all, an Intel 665P or Crucial P2 1TB M.2 PCIe 3.0 SSD will set you back roughly between $95-100, both of which feature speeds that are four to five times faster than the best SATA 2.5-inch or M.2 SATA SSD you can find.

In our case, installing the Corsair Force MP600 was as easy as pie. Simply undo the two Phillips-head screws, lift off the M.2 heatsink, install the M.2 drive, making sure to note where the notch is on the socket and the drive itself, take the film off the heatsink thermal pad, place it carefully back down, and resecure those two screws. There's nothing to worry about here—no LED screens or anything along those lines, just one proficient heatsink to get the job done.

REPUBLIC OF GAMERS
DARK HERO

4 RGB CONNECTIVITY?

OUR SECOND M.2, the Force MP400, has gone in here, in an almost identical manner. Simply undo the two screws, lift up the heatsink, remove the LAIRD film from the thermal pad, insert M.2, rinse, repeat, and you're done—no cables, no fuss, no massive drives taking up space and introducing rogue heat elements. You can also spot that we've filled both of the USB 2.0 headers on this motherboard. One of these runs to the Corsair Commander module that comes with the H150i Elite Capellix cooler, and the other runs to one of the RGB modules that comes with the QL fans.

What's particularly nice about this setup is that it doesn't rely on any RGB headers on the motherboard. Everything plugs in or is connected via the two commander units. For those who've played around with RGB before, you'll know that the software itself is inherently a nightmare to use. Multiple components from different manufacturers each require their own RGB software, and each one intrinsically seems to cause conflicts with those other programs. Even in this case, just using Asus and Corsair as our two manufacturers can lead to issues. In most cases we recommend not installing Asus's ROG Aura software, and just installing Corsair's iCUE and using that to control the lot to avoid any conflicts. Also, because we're not using any RGB headers, our two USB hubs have full control over the nine RGB fans and the pump, minimizing any potential problems.

5 CHUNKY GPU

WITH OUR GPU INSTALLED, this system's starting to look like a real monster by this point. The 6800 XT is a chunky card, but we have one major issue with it, and weirdly it's the reason this build is themed the way it is: the red accents that run all the way around the card.

We live in a digital RGB, multi-colored world now, where we can set lights to do any and all sorts of colors and patterns. Even Razer has dropped its famous green in favor of letting the end user choose what color they want. So why on Earth does this reference design still insist on having that red accenting?

Anyway! Like most GPUs it's a cinch to install. Remove the two PCIe covers from the rear (thankfully it's still a two-slot card), line it up with the port, slot it into place, secure it with the two thumbscrews you removed earlier, and then install your cables. The 5000D doesn't have a direct cable cutout below the GPU, but you can run them from the back near the front I/O headers fairly easily. We quite like this flowy look we've got going on here.

6 ILLUMINATED POWER SUPPLIES

WE'VE USED the CFX RGB power supply from Corsair. It connects via a cable directly to a Corsair Commander unit for its lighting. However, we couldn't get it to register with iCUE on our first attempt or during the photoshoot, though after a quick firmware update at home during testing it was up and running. It's not a bad power supply, but it does raise questions as to whether it's worth having lighting there. To get the most out of it, you need to have the fan facing upward in a chassis like this. You could have it facing downward to get a soft underglow, but it'd be very muted.

The problem with having the fan facing upward is twofold. Firstly, if you do have a leak with the AIO, or if you're running a custom loop, if any coolant leaks into the power supply, it's kaput. On top of that, if the fan's facing down, it's typically got a mesh cover. It pulls cool air from outside the bottom of the case, through a mesh-filtered grille, and pushes hot air out the back. But with the fan facing up, it's drawing in unfiltered warm air from inside the chassis, and spitting that out the back instead. That's technically good for your other components, as you've got one extra exhaust, but less so for your power supply.

7 SIDE-MOUNTED RADIATOR?

WHEN WE saw that you could side-mount a radiator here, we went for it, because that's what it's all about when it comes to testing cases like this. Corsair advises that you install your AIO either in the roof (to allow for push-pull configs), or the front, but we wanted to try sideways. It fits quite well, and gives us a bit of a different angle compared to most other builds in towers like this.

One thing that was slightly annoying, however, was installing the front fans. This isn't necessarily something that's mission-critical or performance impacting, but the front fans, when mounted in the lowest most position, don't line up with the fans on the radiator. We raised the radiator up as much as we could to try and line these up, and got close. It's not the end of the world, but if you've got an obsession with precision, it might not be ideal.

The QL fans, although expensive, are impressive to look at—both the lighting and the rear of these things look good. In fact, despite the ones with the iCUE H150i Elite cooler looking good too, we'd have preferred a third set of QLs.

8 PANEL GAPS

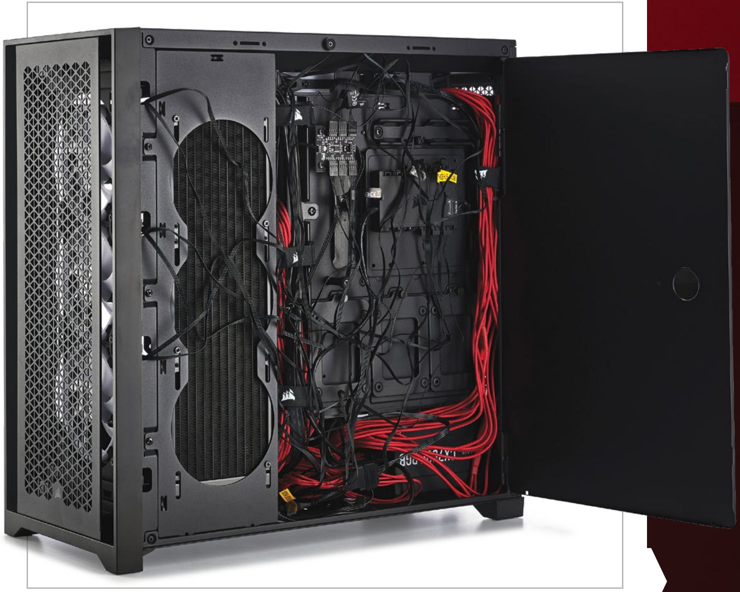
WE MENTIONED installing push-pull configurations earlier with this case in the roof, and here's a really good example of just how easy that is to do. We've removed the top panel in this shot to give you a good idea. You can see that there's a magnetic mesh filter over the top of that, but you can remove this and install an additional set of three 120mm fans, then a radiator underneath, with three more fans equipped, without contacting the motherboard at all. That way you can provide even more airflow and static pressure if you so desire.

We typically haven't seen a huge amount of benefit to running push-pull in radiators. Generally, the industry consensus is that it's not a huge deal. As long as you've got a solid amount of air going over radiators, the limiting factor as far as thermals are concerned is going to be surface area and the radiator's thermal capacity, which isn't something you can usually get around by adding more fans. That said, the gap is very good for standard airflow reasons—the less restriction you have in the way of those fans, the better they're going to be at exhausting hot air out of the top of the case.

9 REAR CABLE MANAGEMENT

AND HERE we have the rear of the 5000D Airflow. You can see the cutout for the radiator on the left, the fan cables we have littered everywhere, and the multiple fan controllers. The case comes with a standard fan controller that plugs directly into a PWM header on the mobo, and can support up to six fans directly. However, it only controls fan speed, not RGB. We're using that to control all of the QL120 case fans—the three in the roof, and the three in the front of the chassis.

The AIO is entirely controlled by the Corsair Commander module that comes with the cooler. We mounted that to the back of the motherboard tray using double-sided adhesive pads that Corsair provided. Theoretically that supports up to six fans, with six RGB headers, and is controlled directly via the iCUE software. However, to keep things simple, we kept all of the AIO fans on the Commander, the QL120 case fans on the integrated fan controller that came with the chassis, and the QL120 case fan's RGB on a separate controller that came with the QL fans (but doesn't control fan speed). Confused? Us too. But it works, and only requires nine fans, three controllers, and 18 separate cables (19 with the PSU).



1 FLOWING GPU CABLES

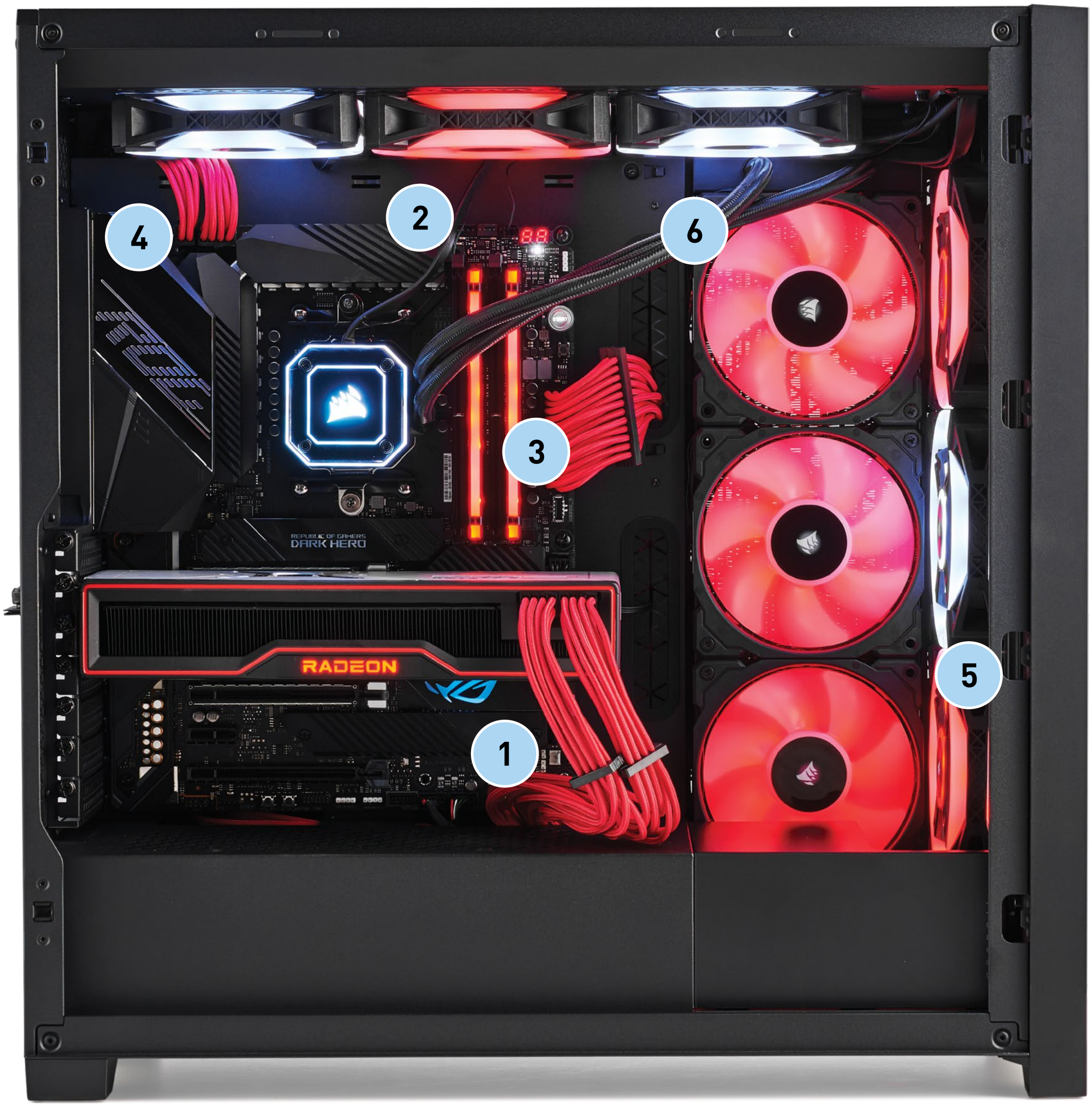
This was generally one of the few happy accidents we had with this build; having the cables here flowing like this, instead of stretched up through a passthrough or to the side, genuinely looks epic.

2 CLEARANCE & AIOS

As you can see, there's plenty of space to install a radiator along with a set of fans, and the mounting location is slightly offset too, so no problems there. However, it is slightly frustrating when it comes to that AIO pump cable running along the top.

3 DOWNLOAD MORE RAM?

We had to have two sticks of memory sadly for the shoot—we're still waiting on Asus to get back to us with a BIOS update to hopefully get the set of four working. But for the time being, 32GB at 3,200 MHz is the name of the game.



4 CABLE KIT

Corsair's Pro cable kit is a nice solution to the basic black cables that come with the CXF RGB power supply. However, the cable combs leave a lot to be desired, and sadly still don't hold a candle to CableMod sets. Still, they're considerably cheaper and accent our build well.

5 ILLUMINATION

The QL fans look incredible. Combined with the Capellix LED in the AIO and the Vengeance memory, it looks impressive. The only things that are a bit of a letdown? The stock fans that come with the H150i, and the lighting in the mobo itself (that ROG logo is actually illuminated, though you can't tell).

6 CABLE TIDY COVER

If side-mounted radiators and fans aren't quite right for you and your next build, then the Corsair 5000D in its standard configuration actually features a classy cable-tidy bar here that hides the lot, and gives you plenty of room to install E-ATX motherboards as well.

CONCLUDING THOUGHTS

AND THERE you have it, one ship-shape 4K gaming PC powered entirely by AMD. We've been wanting to do one of these builds for a while now, just to see what the added benefits are in the real world when it comes to AMD's Smart Access Memory tech.

For those that don't know, when using AMD Ryzen 5000 CPUs (and now 3000-series processors), with a Radeon 6000-series card and appropriate motherboard BIOS (X570 chipset), you can enable Smart Access Memory. This basically gives the processor complete access to the GPU's VRAM.

Traditionally your processor can only ever access up to 256MB of that VRAM at any one time, regardless of how much VRAM the card actually has. The CPU then uses that VRAM as a frame buffer to store information regarding the upcoming frames that the GPU has to render. In this case it could be textures, color values, and so on. Obviously, having a limit of only being able to access 256MB at a time acts as a considerable bottleneck, so the way AMD has got around this is by using the extra bandwidth available from PCIe 4.0 and a few driver tweaks to give the processor unlimited access to the GPU's VRAM.

It's worth pointing out that AMD hasn't patented this, and it's not something that's going to stay only with Team Red. In fact, the company is actively working with Nvidia to get its cards operating in a similar manner with Ryzen processors, and even cooperating with Intel to ensure that Radeon cards work with Intel chips in the same way. Nvidia has also announced that it's working on its own variant of this technology. AMD has stated that this can lead to up to 16-percent performance increases across select titles.

In our testing we found that to be generous. On the whole we saw average improvements of around five to six percent across our testing suite at 4K, compared to it being turned off. That's nothing to be sniffed at, and free performance is free performance. It's likely, as games further advance over the next few years, that developers will be able to take better advantage of the frame buffer because of these improvements, so it could make a serious difference in future titles.

THERE SHE BLOWS

When it came to the actual build process, well it was relatively plain sailing. The only problem we had was something we encountered with the original 4000D, and that's the position of the thumb screws that you need to remove to release the hard drive caddy. They face upwards into the chassis, yet are underneath the power supply cover, and because of that, and the fact they're overtightened during the manufacturing process, they're a nightmare to get out. We ended up using a very long screwdriver and precariously slotting it through one of the cable cutouts near the front I/O headers to get access to it, to loosen them off until we could turn them by hand.

Outside of that it all went swimmingly: the motherboard went in as easy as pie, and mounting the fans didn't present any difficulties. Being unable to perfectly align those side radiator fans with the front case fans was annoying, but not something that would keep us up at night, and cable management could've been a doddle if we'd have taken our time (there's plenty of cable-routing channels, cable covers, and Velcro straps included). It's just a seamless experience building in this thing, and when you get to the end you're left with an exceptionally clean-looking rig. One thing to point out is that if you do go for the vertical GPU route, you'll need to think a bit about how to route the PCIe power cables, as there's no direct PSU cover cutout/passthrough for them.

And the performance? Well, this thing is a beast when it comes to our testing suite. We're comparing this against our Razer Tomahawk ITX build from our Holiday 2020 issue, complete with Core i5-10600K, 64GB of DDR4, and an RTX 2080 Super, to see what it'd be like as a complete upgrade from generation to generation. Unsurprisingly, in the processing department that poor Core i5 is murdered, with the 5950X baring its teeth with a 201-percent performance increase in the multi-core test (and a 30-percent performance increase in single-core tests). PCIe 4.0 SSDs are also markedly faster, topping out near the 5GB/s mark, and on the whole traditional graphical rasterization shows anywhere between a 31-percent and 57-percent increase in average frame rates at 4K.

We don't currently have any ray-tracing titles in our system test suite (we're still waiting for office access for the full setups we discussed last year), but we ran 3DMark's Port Royal ray-tracing benchmark across the two rigs to give us a good idea of what's going on. And even there we're seeing a 34-percent improvement over the RTX 2080 Super. That's still shy of what you'd get from an RTX 3080, but it does slightly edge out the similarly priced RTX 3070. It's worth bearing in mind that this is a purely synthetic benchmark and isn't indicative of what you'll see in games featuring the new tech.

So, for a little over $1,000 more (at RRP) compared to our 2080 Super build, this system leaps over its predecessor. The only title currently not above 60fps is the latest *Assassin's Creed*, and even that averaged 54fps, which is far from unplayable.

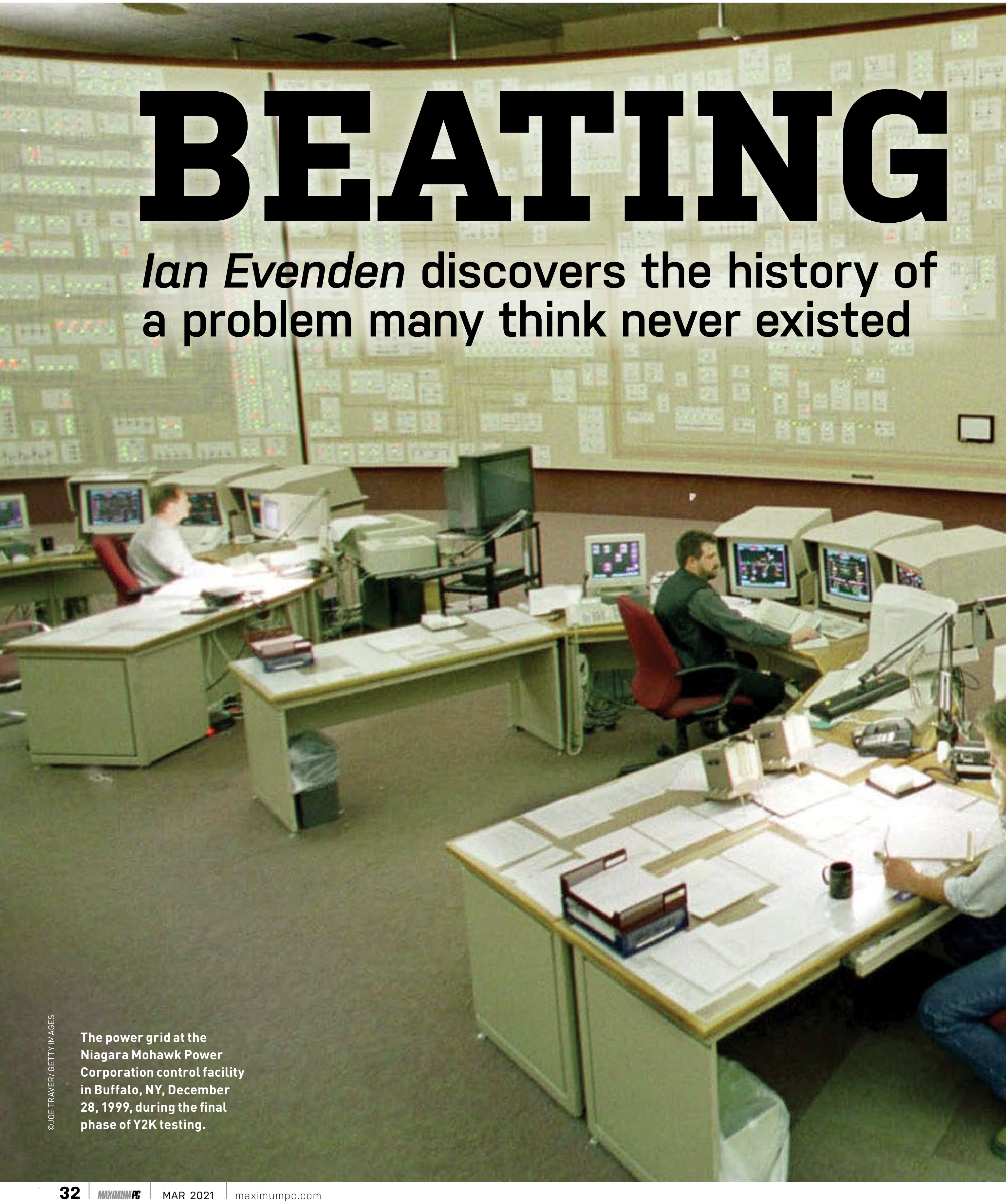
It seems that we're finally starting to cusp over that 4K edge. Perhaps not this generation, but next time 4K may finally become the norm, and we can say goodbye to 1440p and its pesky HD ancestor (that is if there's enough stock, of course).

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,421	4,278 (201%)
CrystalDisk QD32 Sequential Read (MB/s)	3,534	4,985 (41%)
CrystalDisk QD32 Sequential Write (MB/s)	3,170	4,199 (32%)
Middle Earth: Shadow of War (fps)	55	72 (31%)
Total War: Warhammer II (fps)	47	65 (38%)
Shadow of the Tomb Raider (fps)	57	80 (40%)
Red Dead Redemption II (fps)	44	69 (57%)
Assassin's Creed Valhalla (fps)	38	54 (42%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero point consists of an Intel Core i5-10600K, 64GB of DDR4 @ 3600, a Zotac GeForce RTX 2080 Super AMP Extreme, and a 2TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD. All tests were performed at 4K on the highest graphical profile available.



BEATING

Ian Evenden discovers the history of a problem many think never existed

©JOE TRAVER/GETTY IMAGES

The power grid at the Niagara Mohawk Power Corporation control facility in Buffalo, NY, December 28, 1999, during the final phase of Y2K testing.

THE BUG

There was no human sacrifice. Dogs and cats did not live together. The only mass hysteria was in the media. And unlike *Ghostbusters*, the Millennium Bug, also known as the Y2K problem, was very real. It was only through a lot of hard work on the part of programmers and IT contractors across the world that bad things didn't happen. And it's not as if we weren't warned about it years in advance.

For those under the age of 40, here's the condensed version: as the year 2000 approached, warnings increased in the press that, at one second past midnight on January 1, all computers would experience an integer overflow; planes would fall out of the sky, and nuclear reactors explode as a result of catastrophic computer failures linked to the date rollover. This didn't happen, as most computers had been "fixed"—some properly, and others in a way that merely postponed the problem. There were effects, some detrimental and others just annoying, from a date-related integer overflow in 2000, just as there were effects from such bugs before that year. In fact, we continue to feel the effects today. Here's how Y2K unfolded...

WHERE IT ALL BEGAN

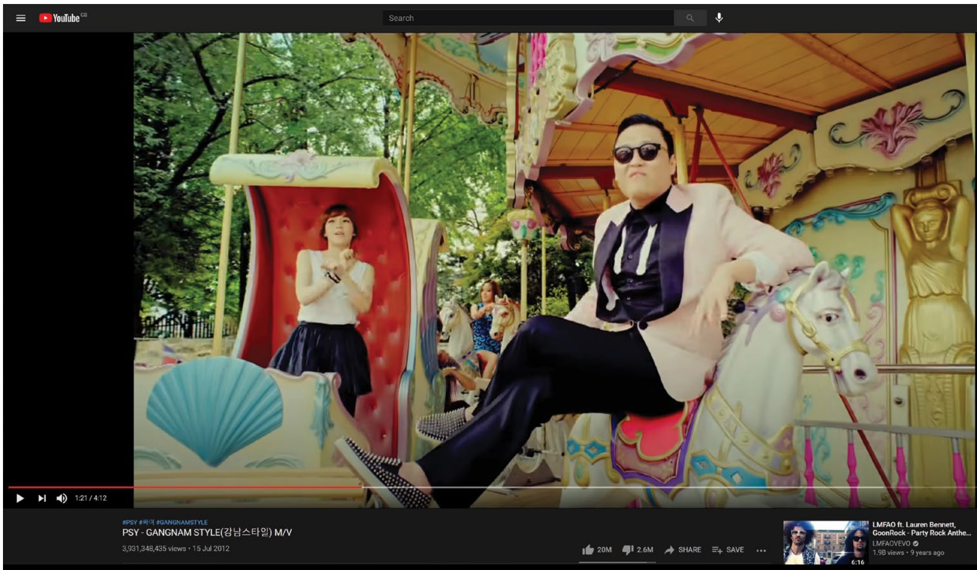
First, Oppa Gangnam Style! The Korean pop hit that taste forgot thrust its way manfully through the eardrums of the world and racked up 2,147,483,647 views on YouTube in 2014. This particular figure was the largest number of views YouTube's backend could support back then, as the site was written with 32-bit integers in mind. A quick upgrade to 64-bit integers later, and Psy's terrifying total could continue its unstoppable upsurge toward the new ceiling of over 9 quintillion views. The basic problem here, an integer overflow, is essentially the same as the Y2K problem.

It all boils down to programmers taking a shortcut, and representing a year with two digits instead of four. This happens absolutely everywhere, despite International Standard ISO 8601 specifying that dates should be written as YYYY-MM-DD. Had computers, particularly embedded systems, used this standardized date format, there wouldn't have been a problem, but computer storage space was once very expensive, and every byte counted, so many programmers used YY-MM-DD, or MM-DD-YY, or DD-MM-YY to save both space and processing time. This all worked fine for a long time, but eventually, due to the way two-digit dates were interpreted, it meant that as 1999 turned to 2000 those systems found themselves in 1900 and, unaccustomed to this time period, either failed or displayed an error.

Another way to think of it is in terms of the odometer in your car. As it passes 99999.9 miles, the final digit clicks around and returns to 0. This causes a cascade reaction through every other digit, returning them all to the same state. It can't generate an extra decimal place, so instead of 100000.0 you get 00000.0. Your car isn't, sadly, returned to factory-fresh condition, but this mechanical wrapping-around of the numbers mirrors what happens in a computer.

Peter de Jager, host of the *Y2K: An Autobiography* podcast and a prolific public speaker on the subject, is often credited with bringing the Y2K problem to widespread attention through a 1993 article in *Computerworld* magazine, but awareness of the problem goes back further than that. IBM computer scientist Bob Bemer noticed it in 1958 while working on family tree software. In the 1970s, banks offering 30-year mortgages bumped into the problem, while in the 1980s the financial industry was forced to take notice, as bonds with expiry dates beyond the year 2000 were issued. By 1987 the New York Stock Exchange had 100 programmers working on the problem, and had spent $20 million on it. The federal government would go on to spend $8.5 billion.

De Jager's article came about as a result of some persuasive tactics with an editor: "I was at an Association for Systems Management meeting, I think in San Francisco," he tells us. "And I'm giving a talk on something very mundane, the PC productivity paradox." This is the slowdown in productivity in the US in the 1970s and 1980s despite rapid development in IT at the time. "There were 300 or 400 people in the room, including this *Computerworld* editor.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3,931,348,435 views • 15 Jul 2012
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LMFAO ft. Lauren Bennett, GoonRock - Party Rock Anthe...
LMFAOVEVO
1.9B views • 9 years ago
6:16

Psy's *Gangnam Style* video on YouTube, showing a seriously impressive 3,931,348,435 views.

Employees monitor the National Command Center for Mastercard International, January 3, 2000. No Y2K problems were encountered.

© YOUTUBE, WIKIPEDIA.

"The federal government would go

PRESIDENT'S COUNCIL ON
Y2K
CONVERSION

John Koskinen of the President's Council on Y2K Conversion speaks with the media during a press conference in Washington, DC, February 29, 2000.

NASA's Deep Impact probe ceased communication in 2013 after its clock reached 2,147,483,647 tenths of a second since January 1, 2000, and overflowed.

© MICHEAL SMITH/GETTY IMAGES, NASA

When I got home, she called me, said she liked the presentation, and asked me to do an article on it. This is back in the day when print media was huge. The old *Computerworld* magazines were like an inch thick, and would drop on your desk every week, the Bible of the IT industry. And I said, 'You have to be kidding. You want me to write about a stupid topic like PC productivity? How about I write about the biggest problem in the IT industry that we're going to face? The fact that we store the year in two digits, and seven years from now this thing is going to go belly-up.' She says, 'Well, OK, you can do that'. It was a little bit of serendipity."

De Jager's article, titled "Doomsday 2000," was called "the information-age equivalent of the midnight ride of Paul Revere" by *The New York Times*. The Y2K

on to spend **$8.5 billion**"

THE 2038 PROBLEM

There are plenty more integer overflow bugs out there, and one of the most prominent involves dates stored on Unix and Unix-like operating systems. While it's fixed on most of the Unix-likes we use commonly, such as Android, macOS, and iOS (early versions of OS X are vulnerable, but the chances are they won't still be in use in 2038), embedded Unix systems like those in factories, medical systems, airplanes, or cars might be still in use—it's only 18 years, after all.

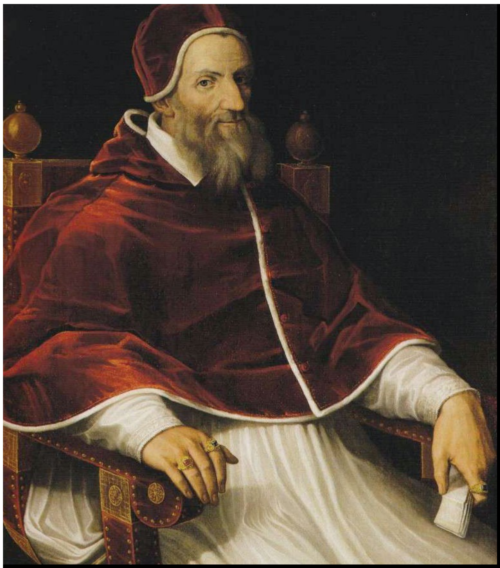
It's also a problem with things like file systems and databases, which have been written with a Unix timestamp in mind.

The problem is this: susceptible systems treat dates as a number of seconds after January 1, 1970. This figure is stored as a 32-bit integer, and the largest possible value that can be stored is 2,147,483,647. This is a lot of seconds, but runs out at 3:10:07 AM on Tuesday, January 19, 2038. After this, it will be interpreted as a negative number, or 8:45:52 PM on Friday, December 13, 1901. It then counts up again, toward zero.

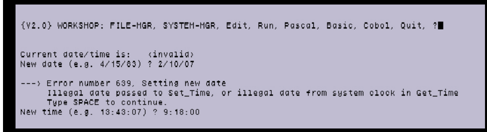
There's no universal solution to this problem, beyond upgrading to a 64-bit OS or architecture. Java, for example, uses 64-bit integers to count microseconds since January 1, 1970, and won't run out of dates for almost 300 million years (it overflows at about 3:30 PM on a Sunday). By then, we might even have received our RTX 3080 cards.

Time and date storage problems are fairly common. Owners of Boeing 787 aircraft —we know you're reading—should be aware that if you don't switch your airplane off at least once every 51 days, you'll get misleading data from it (including important things like altitude and airspeed). And there is, of course, a Year 10,000 problem too, linked to the year having five digits instead of four.

And Windows users should stop looking so smug: that OS's date range runs out in the year 30,828—though that's plenty of time for a patch there.



***Left:* Pope Gregory XIII, the man to blame for the Gregorian calendar system we use today. He came up with it in 1582 after errors in the Julian calendar had caused it to drift by 10 days.**



```
{V2.0} WORKSHOP: FILE-MGR, SYSTEM-MGR, Edit, Run, Pascal, Basic, Cobol, Quit, ?█

Current date/time is:   <invalid>
New date (e.g. 4/15/83) ? 2/10/07

---> Error number 639, Setting new date
     Illegal date passed to Set_Time, or illegal date from system clock in Get_Time
     Type SPACE to continue.
New time (e.g. 13:43:07) ? 9:18:00
```

An Apple Lisa, a computer released in 1983, returns an error when asked to accept a date beyond January 1, 2000.

name would come two years later, in an email sent by Massachusetts programmer David Eddy in 1995: "People were calling it CDC (Century Date Change), FADL (Faulty Date Logic). There were other contenders. Y2K just came off my fingertips," Eddy told *The Baltimore Sun*.

PUBLIC PERCEPTION

There is, as we've hinted, something of a PR problem for Y2K. 20 years on, it's viewed by some as a joke, public hysteria, or a problem conjured up by those keen to sell us new computers and never a real threat. The reality is different: "I don't know of a single person working on Y2K who thinks that they did not confront and avoid a major risk of systemic failure," said John Koskinen, chairman of President Bill Clinton's Council on Y2K, in early 2000. The then-British prime minister, Tony Blair, called it "one of the most serious problems facing not only British business but the global economy today." John Hamre, United States deputy secretary of defense, called it "the electronic equivalent of the El Niño, and there will be nasty surprises around the globe."

Others disagreed. In their book *Running Office 2000 Professional*, published in May 1999, authors Michael Halvorson and Michael Young predicted that most PC hardware and software would be unaffected. "As you learn about the year 2000 problem, and prepare for its consequences, there are a number of points we'd like you to consider," they wrote. "First, despite dire predictions, there is probably no good reason to prepare for the new millennium by holing yourself up in a mine shaft with sizable stocks of water, grain, barter goods, and ammunition. The year 2000 will not disable most computer systems, and if your personal computer was manufactured after 1996, it's likely that your hardware and systems software will require little updating or customizing."

A British startup company, Greenwich Mean Time, took a different view. In 1997 it began selling a software package for £20 (equivalent to $75 today) called Check 2000, which promised to "Check 2000 flags and fix year 2000 PC problems" in "less than the time it takes to drink your coffee." It sold over 4 million copies around the world, and the company's founder, Karl Fielder, was so confident in the patch that he gave his entire staff 10 days' vacation over the millennium turnover, diverting all calls to his cell phone. He got 15.

Estimates of what the world spent on Y2K preparations vary wildly. Whole government agencies were set up, large salaries paid—you can draw parallels with many large human endeavors. And like the Moon landings or the current pandemic, it's a breeding ground for conspiracy theories.

SO WHAT DID HAPPEN?

The US Naval Observatory briefly recorded the year as 19100; 150 slot machines at racetracks in Delaware failed; credit cards with expiry dates in 2000 were rejected because they'd expired in 1900; Telecom Italia sent out bills dated 1900 for the first two months of the year; a radiation alarm system was shut down at a Japanese nuclear power station, and 15 other nuclear reactors around the world had to be shut down (not bad, considering there were 432 in operation worldwide at the time). Planes did not drop from the sky (indeed, Koskinen made sure he was flying at millennium midnight to show his confidence in the measures the US had taken), and military facilities did not burn as a result of the date change. However, the effects were still wide-ranging, despite the amount of work put in.

"The notion that there were no problems is absolutely ridiculous, says de Jager. "We had problems prior to the year 2000, and we identified problems that would have happened if we didn't take care of other problems. There's no debate about it except for people who don't understand." One point of confusion is that some, like Check 2000's customers and those who read the *Office 2000 Professional* book, were using PCs. Windows 98, NT4, and 2000 were robust operating systems that could be patched, and suffered minor Y2K effects involving the display of dates on screen, but little else. "Microsoft understands the critical nature of the Year 2000 issue and is committed to diligently testing its products and promptly providing information and solutions to its customers if issues arise," Rich Kaplan, director of the Platforms Infrastructure Group at Microsoft, said in a statement reported by *CNET*. "In the course of testing efforts with Windows 98, we have identified and fixed these minor Year 2000 issues." The bigger problems came from applications, specialist add-on hardware, and embedded systems that were not so easily updated.

The idea that there were no issues comes, de Jager believes, from "unjustified confidence in computer systems." Y2K, in his view, brought to the fore how reliant society had become on computers. "They sort of snuck into the systems, into organizations. And while IT people knew what they were doing, the C-level executives were sort of saying, 'Yeah, there's that department down there, they're doing something with computers, they seem to be doing it okay, but it's no big deal. And they didn't really realize how much their organizations were depending upon those computers.

"We had to come to them and say, 'Oh, by the way, that stuff that you're depending upon that you don't really understand how much you depend upon? It's all going to go belly-up real soon, and we need to fix it. Could we have $20 million please?' We have an unjustified confidence in our computer systems. Our computer systems are incredibly vulnerable. IT people know this is no secret, but the

"**Planes** did not drop from the sky"

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Jerry and Carolyn Head and their children David, Lesley, and Sarah with their Y2K stockpile (generator, wood, canned goods, etc.) in preparation for possible millennium apocalypse caused by the Millennium Bug.

© STEVE LISS/THE LIFE IMAGES COLLECTION VIA GETTY IMAGES

people who pay for the IT and depend upon it weren't really aware of this until Y2K made people aware."

De Jager saw his goal, at the time, as not being to fix the problem, but to get people to accept the problem existed. "If I'm speaking to an audience, and the overwhelming response is 'He's a nutter, he's absolutely off his head, and I'm going to go back and test our systems and I'm going to prove that he's a charlatan,' then my work has been done. Organizations did go back. They went to their banking systems and they advanced the date on a couple of files, and then they ran their system and the whole thing crashed. Boom. And they went, 'Crap, he's right.'"

Another issue was the assumption that older systems, running older code written in older programming languages whose programmers were, alas, getting older, would be replaced long before the integer overflow became a problem. We've all heard rumors of financial institutions that have built their IT systems on creaking foundations laid down in the 1980s, but could it be more than rumor? "I absolutely guarantee it," says de Jager. "In the US government in many of the states, their payroll systems and their unemployment systems are in COBOL."

COBOL is a programming language that first appeared in 1959, but has been thoroughly and regularly updated through 2014. "There's nothing fundamentally wrong with COBOL, there really isn't," says de Jager. "It's a good product, but it wasn't designed to handle, you know, 20 million people seeking unemployment. These systems are just dying, and dying because they weren't designed to handle that many records. They can make changes to it, but you're just perpetuating the problem. What you really need to do is to go through the old COBOL systems and rewrite and redesign the systems.

"There are Fortran (from 1957, last stable release 2018) programs out there too, I guarantee it. These languages don't die. They sort of continue on in the background. They are immortal."

Finding people who still speak these languages to maintain the systems isn't the way forward, he says. "The real way

WAS THE YEAR 2000 A LEAP YEAR?

Leap years, in which an extra day is inserted at the end of February, come every four years, right? Not so fast. The Gregorian calendar is a bit more complicated than that.

In order to qualify for the extra day, a year needs to be evenly divisible by four. But if it's divisible by 100, it's not a leap year. However, if you can divide it by 400, it is again. This is because the Earth's rotation around the Sun is ever so slightly less than 365.25 days, and over the course of 400 years, you end up with three extra days if you have a leap year every four years. The year 2000, therefore, was a leap year, but 2010 wasn't. And nor was 1900.

That is, unless you use Microsoft Excel. The venerable spreadsheet app incorrectly treats 1900 as a leap year, justifying it as a matter of backwards compatibility with the even more venerable Lotus 1-2-3, which contained the same error.

Fixes for this leap year problem tended to get bundled in with Y2K date fixes, but at other times, the incorrect calculation of leap years, or the failure to accept that they even exist, has caused issues. Witness the freezing of first-generation Zune 30 models on December 31, 2008, though they fixed themselves 24 hours later. In 1996, all 660 computers controlling two aluminum smelting plants in New Zealand and Australia shut down at midnight on December 31, as they couldn't handle a year with 366 days. Sony's PlayStation 3 consoles thought that 2010 was a leap year, which caused errors on March 1 that year. Gmail's chat system, meanwhile, sent all chat records saved on February 29, 2012 back in time to December 31, 1969, and the same year, Microsoft Azure was taken offline on February 28 due to incorrect time calculations.

to solve it is to bite the bullet. Recognize that these things have expiry dates, not because they get bad, but because better solutions come along."

This solution isn't always popular, because of its cost and the length of time it takes to implement. Of course, de Jager has an opinion about this: "People don't realize how expensive this stuff is," he says. "Especially when everything depends upon it. When your entire organization is depending upon 50,000 programs written in an arcane language, replacing it is not an overnight task. It takes four or five years. We have examples of payroll systems that need to be replaced all over the world. In New Zealand, they tried to replace the teachers' payroll system, and teachers didn't get paid for a year. In Canada we have something called the Phoenix system, which is supposed to replace all the huge payroll systems for the government, and we're still having trouble with that." Indeed, Canada's Standing Senate Committee on National Finance called Phoenix an "international embarrassment" in a 2018 report.

"We don't really appreciate how complicated this stuff is," de Jager says. "We think we'll just do it. You know, here's a couple of million dollars, just take care of it. It's not that easy."

LESSONS ON COOPERATION

We sat down with the president and CEO of the EastWest Institute, Bruce McConnell. McConnell served for four years as deputy under secretary for cybersecurity at the US Department of Homeland Security, and led the International Y2K Cooperation Center (IY2KCC) as its director for the UN and the World Bank.

MAXIMUM PC: How did you become the director of the IY2KCC?

BRUCE MCCONNELL: In mid-1998 I was serving as the chief of information and technology policy in the US Office of Management and Budget. Y2K preparedness of the US government departments and agencies was a principal focus of my office's activity. The president had recently appointed a "Y2K Czar," John Koskinen, who was responsible for coordinating all US preparations. As John got into the issue, he realized that Y2K was a problem that would not respect national boundaries. Working with the United Nations and the World Bank, John and his UK counterpart organized governmental contributions to the World Bank that, along with funding from other countries, created the IY2KCC... the White House seconded me to stand up and run the organization, where I served until we closed down in March 2000.

MPC: What did the IY2KCC achieve?

BM: The IY2KCC did not solve the Y2K problem; it made the work of those who were solving it more efficient and effective. We did so by establishing a global community of people working to remediate the Y2K bug, representing 159 countries and organized along regional and sectoral lines. These subcommunities shared knowledge about what devices were vulnerable to failure and which were not, and about techniques that worked to remediate them. For example, there was concern that elevators might malfunction and drop to the ground. A team based in Germany and Japan investigated elevator control systems and found that only one high-end Japanese system had vulnerability, and that the vulnerability would not cause the elevator to drop, only to stop functioning. We helped the team disseminate this information on a global

techradar.

Bruce McConnell has vast reserves of knowledge when it comes to cybersecurity.

basis and saved a lot of people time to work on other... vulnerabilities.

Our regional communities were quite successful in identifying interconnections, such as power grids, between neighboring countries. For example, the Latin American group produced the first-ever coordinated map of high-voltage transmission lines in South America, which enhanced cooperation on Y2K, and later, on other power reliability work...

In September 1999, we correctly predicted that the consequences of the bug were likely to be modest. As that report noted, the key issue at that point had become avoiding panic, i.e., reassuring the public that all the work that people around the world had done was sufficient to limit the impact, and that there would be no major crisis. Our work contributed to maintaining a general calm around the crisis, at least for most people.

MPC: What would have happened if action had not been taken?

BM: The most serious vulnerabilities were to be found in financial systems. Many governmental and private sector financial systems, including taxation systems, stock markets, and banking transfer systems, had been among the first efforts [of] large-scale computerization. With software code dating from as far back as the 1970s, many of these systems relied on two-digit dates and... calculations about how much time had elapsed between two dates. Further, the code was often poorly documented and no one actually knew how everything interacted, making the possible impacts difficult to predict.

Without remediation, it was likely that major systems which business and governments depend on to make the global economy function would fail in various ways, either by shutting down, or, possibly worse, by providing unreliable results. In either case, public loss of confidence could have wreaked economic havoc and social unrest.

An example of long-term impact can be found after 9-11. The New York Stock Exchange had developed testing scenarios to validate the functionality of its core systems. When the exchange was closed because of the World Trade Center attack and associate[d] damage in lower Manhattan, the operators brought up the backup site, and used the Y2K testing suites to validate functionality. If those suites had not already been developed, the market would have been done for weeks...

MPC: What can be learned from Y2K?

BM: The principal lesson is that, faced with a global threat that cuts across national boundaries and involves every sector of the economy, a successful way of proceeding is to create a loosely-coordinated, cross-disciplinary, global community of people who want to solve the problem, and then facilitate their working together. The IY2KCC worked with all global powers through the United Nations. One can imagine if such a mechanism had been established a year ago, perhaps with the cooperation of major powers and the World Health Organization, we might be in a better place than we are today.

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Missile Commanders confirm a launch warning over the phone during a practice drill at the North America Aerospace Defense Command (NORAD) Cheyenne Mountain Complex in Colorado Springs, Colorado, November 9, 1999, in the run-up to the new millennium.

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IT'S NOT OVER YET

And the way Y2K was fixed may come back to haunt us in the future. A technique called "windowing" was often used, where instead of rewriting computer code to allow for four-digit years, it was instead modified so that dates within a specific window—for example 00-20—were recognized as beginning with 20, and all others with 19. This method kicked the can down the road, setting another hard deadline by which time it was assumed that the devices would have been replaced. Guess what?

"We saw Y2K problems occur in 2020, and we could make that prediction because we knew that the problem wasn't fixed," says de Jager. "It was pushed to the future instead of expanding to four-digit years. What we did was, we used things like windowing, and one of the windows that we used was 20 years. It'll certainly rear its head again in 2025, again in 2030, and 2050, because those were all the dates used for windowing."

Known 2020 glitches included *WWE 2K20*, a bafflingly popular wrestling videogame that became non-functional until a patch was pushed out; cash registers that were manufactured by Novitus stopped being able to print receipts until fixed; and yet more utility companies produced bills dated 1920.

The year 2020 was often picked for windowing for a reason: Unix. The operating system that just won't die, Unix originated at Bell Labs in 1969. It lurks in things like Android and macOS, and counts time in a particular way related to seconds since January 1, 1970 (see boxout, P35), and the year 2020 is exactly 50 years after 1970. Again, no "fixed" systems were expected to still be in operation by the time 2020 came around, and the executives who ordered such cost-cutting didn't expect to still be in their roles when it came back to bite them either.

Our society still hasn't come to terms with its reliance on computers. We tend to think that, if they all disappeared tomorrow, everything would be okay. The truth is that computer failures kill people—look at Boeing's 737 Max airliner, grounded worldwide after 346 people died in two crashes caused by automated flight-control malfunctions. If we hadn't done anything about Y2K, then the consequences could have been disastrous—even de Jager won't be drawn in on a potential worst-case scenario. "There's no way to know," he says. "We knew things would go wrong, but there's no way to predict with any certainty what could go wrong."

Former *CNN* science editor Kevin Sanders, writing in *The Nation* in

"The greatest danger comes from **Russian and Chinese missiles**"

Console grapplefest *WWE 2K20* had a buggy launch in 2019, but stopped working completely once 2020 actually rolled around.

© 2K GAMES/2K SPORTS,

February 1999 was prepared to go there, however: "The greatest danger comes from Russian and Chinese missiles," he wrote. "As the Y2K digital tsunami moves west from the international date line in the Pacific, China and Russia will become the first nuclear nations to face possible computer failures—almost half a day earlier than the United States. All contact and communications could be lost or disrupted. Launch-site commanders could be left literally in the dark, trying to read the meaning of silence."

The article continues: "According to a number of Russian scientists currently working in the United States, the financially starved Russian military and its dilapidated computer systems are even more prone to Y2K failure than those in the United States… Sergei Fradkov, a former Soviet satellite control technician now working for a Wall Street software developer [says], "Russia is extremely vulnerable to the Year 2000 problem… If the date shifts to 0 for a brief moment… that fools the system into thinking there is a high probability of an attack in progress."

At that time, Russian and Chinese nukes were no longer targeted at US cities, but this didn't stop the speculation: "[T]hey can be back on target in ten seconds. Whether this could happen as the result of an automatic or accidental computer default is not known." Everything in the US was A-OK, however; Captain Allan Toole, head of the Pentagon's Y2K Special Weapons Agency, was quoted in the same article, saying, "I have a good feeling about Y2K in this agency." So that's all right then.

In July 1996, Senator Daniel Patrick Moynihan (D-N.Y.) wrote to sax-playing White House resident Bill Clinton. "The computer has been a blessing," he wrote. "If we don't act quickly, however, it could become the curse of the age… each line of computer code needs to be analyzed and either passed on or be rewritten." That effectively did happen, whether it was a long-term fix, an emergency patch after problems developed, or windowing that simply pushed the problem into the future.

Legions of IT professionals stepped up to squash the bug, millions of home users installed patches, and its worst effects were mitigated. And this is something that rings through to the present day, and transcends the narrow world of computing: when we all work together, we can move mountains. ⏻

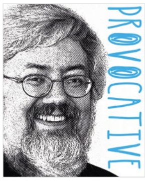
MODERN-DAY PARALLELS

"When people used to say that Y2K was a hoax, it used to annoy me," says de Jager. "Now I just laugh. It's like people saying that COVID doesn't exist.

"I've been watching COVID right from the start, been watching the curves, and this is all about curves. This is all about epidemiology and how things move. If you don't change the conditions, that curve will continue to do what that curve is doing, you know. 4,000 people died yesterday, yeah, and you're gonna see 4,000 people today and for the next 20 days.

"People do not respect science. For one thing, they don't understand it because our education systems have failed everybody. And we have people, you know, believing the Earth is flat, and COVID doesn't exist, and it's all a myth, and that masks don't work.

"There were two things with Y2K that worked to our advantage. One, the message was pretty consistent. Yes, we had some outliers saying it wasn't real. We had a lot of reporters and journalists who didn't know anything about systems saying this was nonsense. And you can sort of discard them because they weren't having any influence on the people actually out there fixing the problem. Two, there was a freaking deadline. A date that we had to get this thing done by. And that really concentrated our efforts.



Peter de Jager is a keynote speaker, writer, and consultant, focusing on the issue of managing change across organizations. He is most widely known for his work raising awareness of the Y2K bug.

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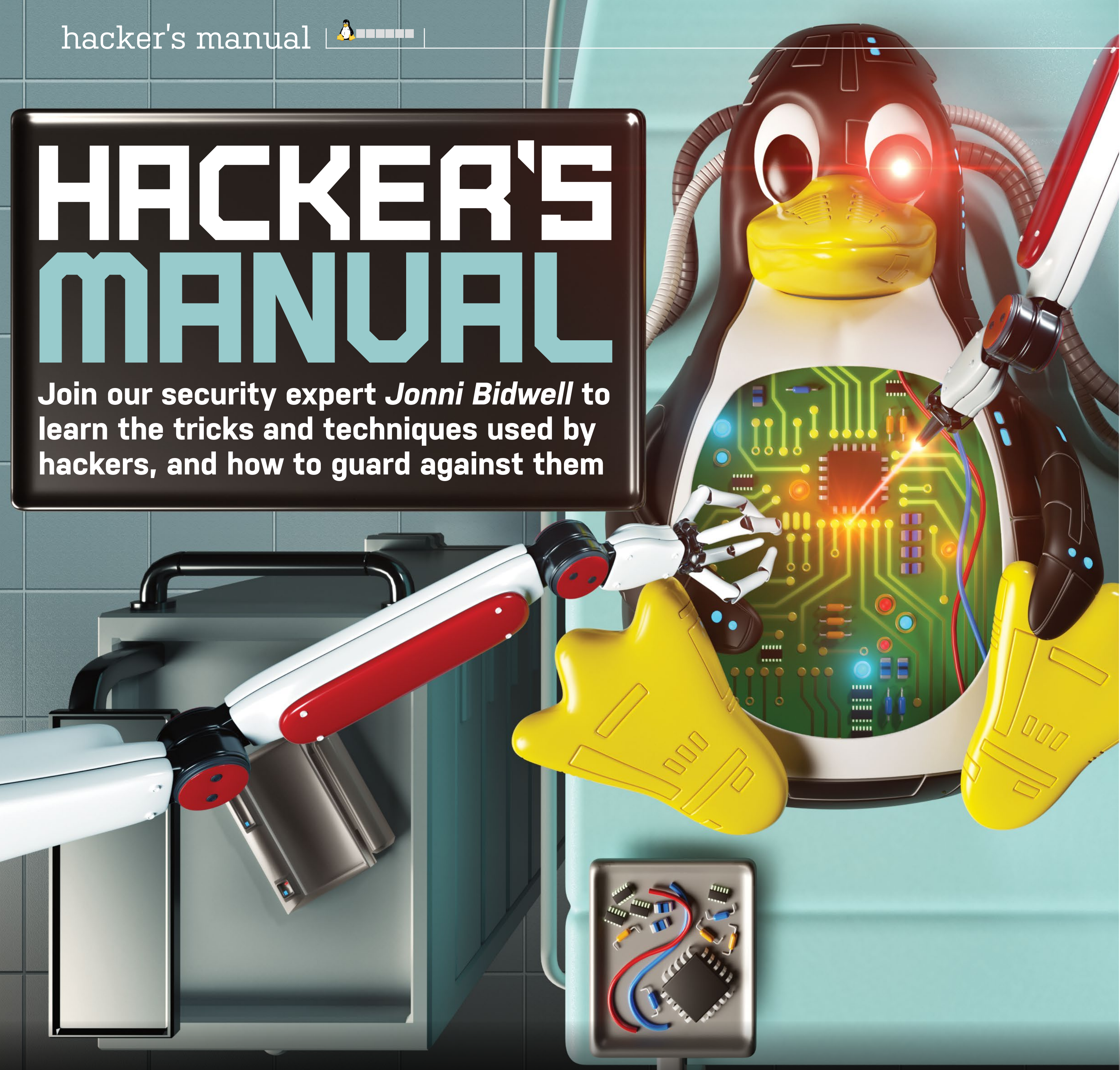
HACKER'S MANUAL

Join our security expert *Jonni Bidwell* to learn the tricks and techniques used by hackers, and how to guard against them



THE 1995 MOVIE *Hackers* has a lot to answer for. Not only was there egregious product placement for a certain fizzy beverage with red and white branding, but it helped reinforce the notion that hacking was all good-looking edgy types breaking into computers and causing havoc.

Today that notion (along with the idea that an oversized black hoodie and *V for Vendetta* mask are essential attire for this hacking) is fairly entrenched among the non-tech savvy, reinforced by unlikely movies and shoddy media reporting.

Readers of this fine publication ought not to buy into that. "Hacking" originally meant the breaking, modifying, and repurposing of technology so that it functions differently to how the manufacturer intended. Today, many programmers call themselves hackers, and only a small fraction of those are up to no good.

Be that as it may, we have been asked to write a feature on hacking, and we're pretty sure they mean the bad kind. But please don't go getting yourself into any trouble. Sure, here we'll show you how to use Kali Linux, Metasploit, and other tools. We'll show you the rudiments of SQL injection, buffer overflows, and other vulnerabilities. We'll even show you how to exploit them. But we won't show you how not to get caught. And if you do get caught, you could face serious charges, so don't do any of this on systems that aren't yours. These tools and techniques are used by legitimate penetration testers to find weaknesses and secure them, and that's why we're sharing them here.

Of course, not everyone is as scrupulous and there are plenty of amateur "how to hack" guides online. So we'll show you how to trick those nefarious hackers and bots with a Raspberry Pi honeypot.

© MAGICTORCH/FUTURE

HACKING THROUGH THE AGES

From phone lines to fake certificates and social engineers, hacker tradecraft has evolved spectacularly over the years

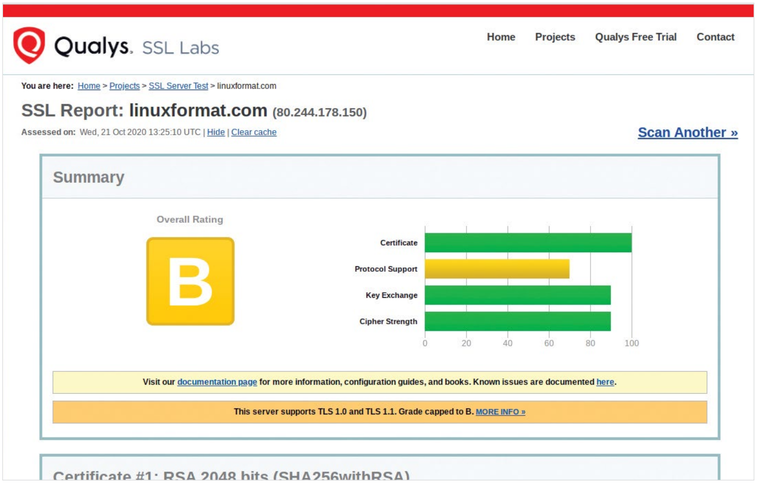
PEOPLE HAVE DONE BAD THINGS with computers for decades. Even before personal computers, people ("phreakers") used to abuse telephone systems. The hacking journal *2600* takes its name from the 2600Hz tone required to trick AT&T phone lines into giving free calls in the 1960s. This was possible because the same line carried both voice and connection-management signals.

Such in-band signalling was done away with in the 70s when a new signalling system was introduced. This enabled different networks to send this data out of band. This system, known as SS7, is still in use today, and is vulnerable to a man-in-the-middle attack. This has been exploited to allow second-factor SMS codes to be intercepted, and accounts to be compromised.

The Morris Worm is widely regarded as the first self-replicating worm to spread over the internet. It was actually a well-intentioned effort to highlight security flaws and count the number of computers on the internet, but an error led to it crippling somewhere between 2,000-6,000 of them (watch *Halt and Catch Fire* S2 E3). Robert Morris won the dubious honour of being the first person convicted under the Computer Fraud and Abuse Act (CFAA), but post-conviction completed his Ph.D. at Harvard and went on to be a professor at M.I.T.

THE WORM THAT TURNED

The worm exploited a number of vulnerabilities in Unix tools, as well as weak passwords. The problem was re-infection. Morris didn't want his worm to have to ask targets if they were infected and then infect them only if they replied no—this could be stopped by canny sysadmins installing a program that just says yes all the time. So he specified that one-seventh of the time machines would be re-infected. This, it turns out, was high enough that machines quickly ended up running several copies of the worm and became unusable.



You are here: Home > Projects > SSL Server Test > linuxformat.com

SSL Report: linuxformat.com (80.244.178.150)

Assessed on: Wed, 21 Oct 2020 13:25:10 UTC | Hide | Clear cache

Visit our documentation page for more information, configuration guides, and books. Known issues are documented here.

This server supports TLS 1.0 and TLS 1.1. Grade capped to B.

Certificate #1: RSA 2048 bits (SHA256withRSA)

Even our venerable friends over at linuxformat.com have something to learn from this month's feature.

Fast-forward to today, and in the headlines we see not only that rogue packages have been hiding in the NPM registry for years and opening shells on JavaScript developers' machines, but also that several Russian individuals have been indicted in the US for attempting to disrupt the 2017 French presidential election, the 2018 Winter Olympics, and Ukraine's power grid. The groups with which these hackers affiliate, it's alleged, all report to Russia's GRU military intelligence unit. It's a little chilling to be reminded that critical infrastructure may be compromised relatively easily.

The Stuxnet worm is widely believed to have been developed by the US and Israel. It was discovered in 2010 targeting Supervisory Control And Data Acquisition (SCADA) systems in Iran, where it's estimated to have crippled one-fifth of their nuclear reactors. The worm was notable because of its ability to attack airgapped (not directly connected to the internet) systems, by exploiting vulnerabilities in how they handled USB devices.

WHITE HAT HACKING

There's a school of thought that says we (or anyone) shouldn't provide information that budding hackers could use to cause damage or distress. In February the UK's West Midlands Regional Organized Crime Unit even launched a poster campaign naming and shaming Tor, Kali Linux, and Metasploit, and urging parents to check that their children aren't turning into evil hackers.

But we think differently. By understanding these techniques and having the tools at our disposal to execute them in a responsible way, we can help to create a more secure computing space for everyone.

Penetration-testing is big business nowadays, and companies pay more money than they'd like to admit to have people (red teams) actively try to break into their systems. Meanwhile, blue teams have to do everything within their power to shore up the defences and detect, contain and clean up these intrusions.

There are university-level courses on information security that cover the ins and outs of breaking crypto, return-oriented programming and attacks on the stack. There are even places to learn the ins and outs of social engineering, such is the scale on which it's employed.

© QUALYS

INTRODUCING KALI

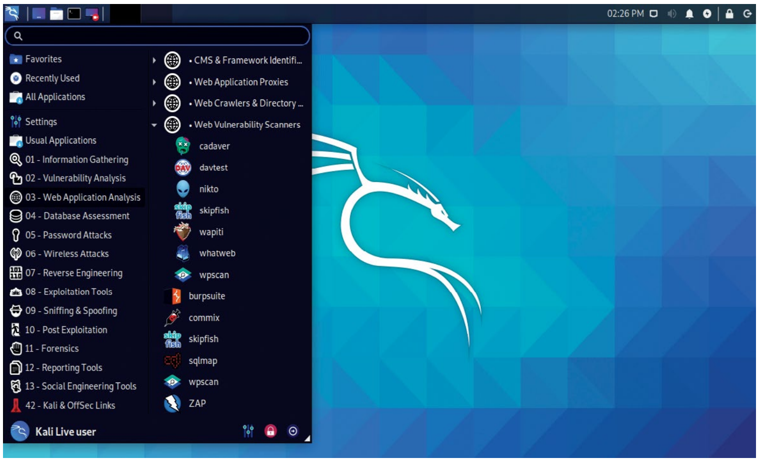
Kali Linux is a powerhouse of pen-testing and security research goodness

THE TOOLS WE'RE GOING TO SHOW you can be installed on pretty much any Linux distro, but we're going to use Kali Linux. This is primarily because it has all these tools installed already, and there's excellent documentation if you want some more information about it.

Kali is probably not something you'd want to use as a daily driver, although if you look online you'll see a lot of posts by budding haxors that do just this. Up until the end of last year Kali used the root account by default, since many tricks such as handcrafting network packets require this. It would be a terrible idea if you were running, say, your mail client as root and you clicked a dodgy link.

Using the root account was sound practice so long as you kept the system "clean" of any of your (or other users') personal affairs. In fact, the risk is often overstated on a single user machine where that user typically has sudo access anyway. However, many applications also require a non-root account, since running them as root presents a security risk.

Kali Linux is packed with everything you need to start your hacking career.


02:26 PM
Favorites
Recently Used
All Applications
Settings
Usual Applications
01 - Information Gathering
02 - Vulnerability Analysis
03 - Web Application Analysis
04 - Database Assessment
05 - Password Attacks
06 - Wireless Attacks
07 - Reverse Engineering
08 - Exploitation Tools
09 - Sniffing & Spoofing
10 - Post Exploitation
11 - Forensics
12 - Reporting Tools
13 - Social Engineering Tools
42 - Kali & OffSec Links
• CMS & Framework Identifi...
• Web Application Proxies
• Web Crawlers & Directory ...
• Web Vulnerability Scanners
cadaver
davtest
nikto
skipfish
wapiti
whatweb
wpscan
burpsuite
commix
skipfish
sqlmap
wpscan
ZAP
Kali Live user

So now Kali has adapted, and root is no longer the default (the default username and password are both "kali"). However, you still shouldn't use it as a daily driver. You will run into oddities with networking, Bluetooth and package availability, since all these things have been tweaked, either to minimize the attack surface or to make things easier for launching attacks. Perhaps this is why Parrot beats Kali. Parrot is more like a regular distro, with security tools, while Kali is more focused on security and pen-testing. There's no LibreOffice, and because it's based on Debian some repositories are disabled, so installing additional software may not be as easy as you would expect.

LAUNCHING KALI

You don't even need to install Kali Linux. You can run it from the live environment, either on bare metal or in a virtual machine. So long as you're sure you're using an official Kali image, this will ensure that your other data remains intact—security by separation is good practice, after all. But then again so is keeping your system updated, and it's frustrating to have to do that every time you boot Kali, so an installer is available. It's also possible to create a Kali Live USB stick with persistent storage, which makes life easier if your security business involves gathering data. See www.kali.org/docs/introduction/download-official-kali-linux-images to check the image is official. If you find yourself downloading a newer version, be sure to do so from the official website, and follow the checksum and signature-checking instructions.

Kali Linux uses the Xfce desktop—even if you're not familiar with it, it should be easy to navigate. What may be a little overwhelming is the huge amount of stuff packed into the initial install. Fortunately, everything has been categorized in the Applications menu. We don't have enough space to

PORT AUTHORITY

Port scanning is one of the most common first steps towards assessing the security of a particular machine. There are a few ways of doing it, but they all involve attempting to open a connection to various ports on the target machine to see which ones have services running on them (for example, webservers run on TCP ports 80 and 443).

Nmap is one of the most useful port-scanning tools. Fire up a terminal in Kali and run

```
$ nmap localhost
```

This will scan the 1,000 most common ports on which services are found. On a default Kali install no services should be running and that command should tell you as much. Nmap by default uses stealth scanning, which only partially opens connections. This makes it harder to detect scans, though a keen-eyed sysadmin poring over a Wireshark packet capture could still spot them. If you run Nmap as root, you'll sometimes obtain a little more info about the target machine and the software it's running. Over the page you'll see how we can use this to find the IP addresses for the many Raspberry Pis on our LAN. Being root also enables you to send raw packets, so there's no need to connect to the target machine. Nmap even has a paranoid stealth mode (which is much slower so as not to trigger detection systems; activate it by adding `-T0` to its arguments.

There are other scanners with different purposes. For example Masscan can port scan the whole Internet in about six minutes.

© KALI

talk about everything, but we can cover the basics, and if you're lucky a couple of more advanced topics. So fire up Kali, open up a terminal, and carry out some reconnaissance against our own machine, by following the guide in the box (below left).

At this point you can start using some of the tools in the Kali arsenal to probe machines on your network. Or you could run Kali in a VM and then set up another vulnerable virtual machine and start attacking that. VirtualBox's Internal Network option is good for this, as it enables VMs to communicate with one another while isolating them from physical hosts on the network. There are several toy VMs and applications available to practise this on. We'll look at some of these over the page. The most popular is the Metasploitable (a pair of deliberately vulnerable VMs running Windows 2008 and Ubuntu 14.04), which is provided by Rapid7—the same people who make Metasploit Framework.

GET 'SPLOITING!

Metasploit Framework is one of the most powerful security tools out there. From its command line interface you have immediate access to thousands of exploit ("sploit") modules, and many more are available from the community. Each module has a variety of parameters, but commonly just a target IP address is required to launch an attack. You'll find Metasploit in Kali's Exploitation Tools menu, or you can start it from the terminal with a simple `msfconsole`. Metasploit features a hierarchy of modules sorted into categories, such as `auxiliary` (things like port scanners and fuzzers), `exploits` (code for exploiting vulnerable systems), and `payloads` (things to execute on a remote machine that's been pwned by an exploit).

There are tools to craft and disguise custom payloads. One of the most useful is a reverse shell, which is like a regular shell, only it connects to you. This is handy if one of your targets is behind a firewall and can't be directly connected to. All an attacker needs to do is make sure a listening service is set up on their machine, and that the service is reachable from the outside. Metasploit has its own Meterpreter shell that can be used for this purpose. All communication with the shell is encrypted, and nothing is written to disk, so it'll be as if you never were there, hypothetically. Not all exploits allow remote code to be executed, but that's not always necessary.

The Heartbleed vulnerability (CVE-2014-0160) was a buffer overflow in OpenSSL that enabled an attacker to read privileged memory and steal passwords, certificates and other private data. Unlike many other bugs, it's easy (with the benefit of hindsight) to spot the mistake in the code. To keep connections alive, the software introduced a "heartbeat" feature, where a client could send a small amount of data to the server, which would echo it back. Unfortunately, it was possible for a client to send a malicious heartbeat request, a single byte long, and request up to 64K back from the server. Because only a single byte was allocated, OpenSSL would read past the end of the buffer and return a random 64K chunk of memory. This may not sound like much, but the attack could be quickly and repeatedly carried out. We may never know if anyone discovered this bug before it was actually announced, but distros quickly patched it afterwards.

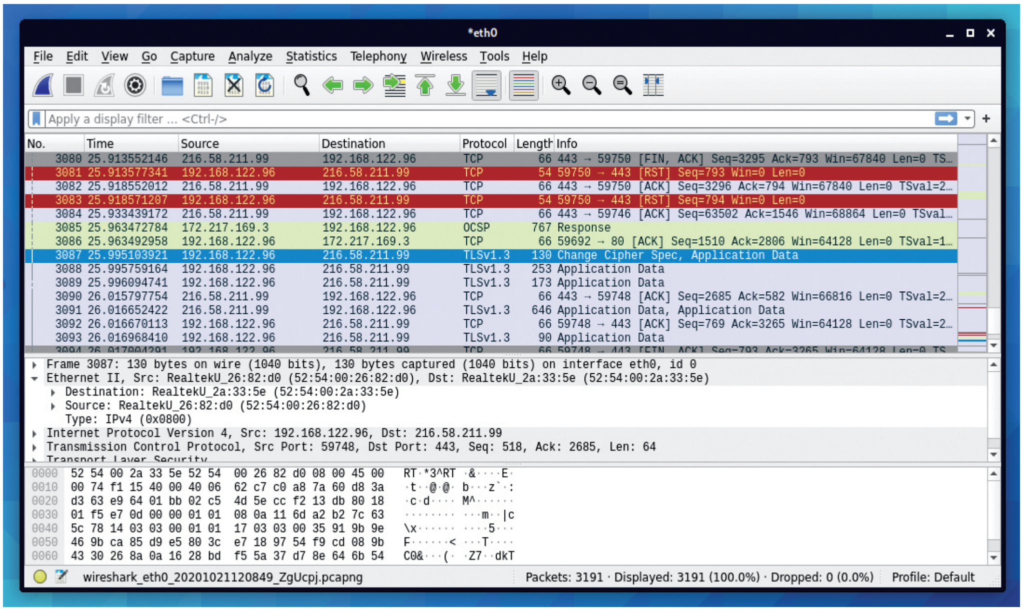
To attempt a Heartbleed attack on a server on your network is very easy (it's also easy to do against remote hosts, but don't do that). From Metasploit just do:

```
> use auxiliary/scanner/openssl_heartbeat
> set verbose true
> set RHOSTS 192.168.x.x
> run
```

We hope you're not running a vulnerable version of OpenSSL on your server, but at least this way you'll know.

Heartbleed was notable not just because of its severity, but because it was the first bug to get its own logo, too.

© HEARTBLEED.COM



*eth0
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.   Time         Source          Destination     Protocol Length Info
 3080 25.913552146 216.58.211.99   192.168.122.96  TCP        66 443 → 59750 [FIN, ACK] Seq=3295 Ack=793 Win=67840 Len=0 TS…
 3081 25.913577341 192.168.122.96  216.58.211.99   TCP        54 59750 → 443 [RST] Seq=793 Win=0 Len=0
 3082 25.918552012 216.58.211.99   192.168.122.96  TCP        66 443 → 59750 [ACK] Seq=3296 Ack=794 Win=67840 Len=0 TSval=2…
 3083 25.918571207 192.168.122.96  216.58.211.99   TCP        54 59750 → 443 [RST] Seq=794 Win=0 Len=0
 3084 25.933439172 216.58.211.99   192.168.122.96  TCP        66 443 → 59746 [ACK] Seq=63502 Ack=1546 Win=68864 Len=0 TSval…
 3085 25.963472784 172.217.169.3   192.168.122.96  OCSP      767 Response
 3086 25.963492958 192.168.122.96  172.217.169.3   TCP        66 59692 → 80 [ACK] Seq=1510 Ack=2806 Win=64128 Len=0 TSval=1…
 3087 25.995103921 192.168.122.96  216.58.211.99   TLSv1.3   130 Change Cipher Spec, Application Data
 3088 25.995759164 192.168.122.96  216.58.211.99   TLSv1.3   253 Application Data
 3089 25.996094741 192.168.122.96  216.58.211.99   TLSv1.3   173 Application Data
 3090 26.015797754 216.58.211.99   192.168.122.96  TCP        66 443 → 59748 [ACK] Seq=2685 Ack=582 Win=66816 Len=0 TSval=2…
 3091 26.016652422 216.58.211.99   192.168.122.96  TLSv1.3   646 Application Data, Application Data
 3092 26.016670113 192.168.122.96  216.58.211.99   TCP        66 59748 → 443 [ACK] Seq=769 Ack=3265 Win=64128 Len=0 TSval=2…
 3093 26.016968410 192.168.122.96  216.58.211.99   TLSv1.3    90 Application Data

▸ Frame 3087: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface eth0, id 0
▾ Ethernet II, Src: RealtekU_26:82:d0 (52:54:00:26:82:d0), Dst: RealtekU_2a:33:5e (52:54:00:2a:33:5e)
  ▸ Destination: RealtekU_2a:33:5e (52:54:00:2a:33:5e)
  ▸ Source: RealtekU_26:82:d0 (52:54:00:26:82:d0)
    Type: IPv4 (0x0800)
▸ Internet Protocol Version 4, Src: 192.168.122.96, Dst: 216.58.211.99
▸ Transmission Control Protocol, Src Port: 59748, Dst Port: 443, Seq: 518, Ack: 2685, Len: 64

0000  52 54 00 2a 33 5e 52 54  00 26 82 d0 08 00 45 00   RT·*3^RT ·&····E·
0010  00 74 f1 15 40 00 40 06  62 c7 c0 a8 7a 60 d8 3a   ·t··@·@· b···z`·:
0020  d3 63 e9 64 01 bb 02 c5  4d 5e cc f2 13 db 80 18   ·c·d···· M^······
0030  01 f5 e7 0d 00 00 01 01  08 0a 11 6d a2 b2 7c 63   ········ ···m··|c
0040  5c 78 14 03 03 00 01 01  17 03 03 00 35 91 9b 9e   \x······ ····5···
0050  46 9b ca 85 d9 e5 80 3c  e7 18 97 54 f9 cd 08 9b   F······< ···T····
0060  43 30 26 8a 0a 16 28 bd  f5 5a 37 d7 8e 64 6b 54   C0&···(· ·Z7··dkT

wireshark_eth0_20201021120849_ZgUcpj.pcapng   Packets: 3191 · Displayed: 3191 (100.0%) · Dropped: 0 (0.0%)   Profile: Default
```

Wireshark enables you to capture network packets straight off the wire, so you can see network traffic in real time.

DISRUPTING DATABASES

Get your first taste of breaking something in the form of a deeply vulnerable web application

IN THE PAST we'd have directed you to hack by setting up the Metasploitable virtual machine and attacking it. We'd encourage you to do that too, (you'll find all the information you need at https://github.com/rapid7/metasploitable3). But this time around we're going to do something different. The Damn Vulnerable Web Application (DVWA) is exactly what you might expect: it's a PHP application riddled with security holes. It requires a LAMP (Linux Apache MySQL PHP) stack to run, and it's certainly not the sort of thing you want to deploy on an internet-facing server. So rather than set all that up from scratch, we'll cheat and use the Docker image. Just follow the simple three-step guide (below). We can't get enough of Portainer, so if you're similarly enamoured with this container management solution, by all means use it to do the first step of the step-by-step guide.

Before you do that, though, let's talk about Structured Query Language (SQL). It's how you interact with databases. On Linux this is usually to a MySQL or MariaDB database. Such databases often sit behind web servers running PHP applications (such as Wordpress). And very occasionally those databases or the applications relying on them are broken because someone figures out a way to inject some rogue SQL, often by typing something peculiar-looking into a web form. The classic example is to input something like:

```
'; DROP TABLE users;
```

into a form, and have the database suddenly forget about all the users of the application. This generally doesn't work anywhere now, but when it did, it did so because behind the scenes that form sent its input (unchecked!) to a query of the form:

```
$sql = "SELECT username from users where
username = '$user';"
```

If we substitute our malicious entry above into the `$user` variable above, and reformat things slightly, our query becomes:

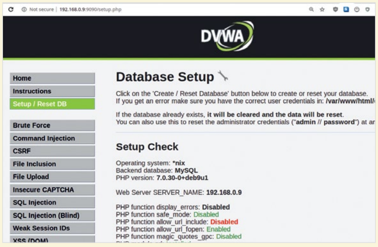
```
SELECT username from users where username
= '';
DROP TABLE users;
';
```

And you can see why this is bad. SQL injection has been around since the end of the 1990s and continues to plague applications today. This, despite there being no shortage of PHP functions for sanitizing input—all the easy attacks stop working if you don't allow punctuation in your forms. Indeed, crudely building SQL statements like this is more or less asking for trouble. Even if the previous example doesn't work anymore (because chaining SQL statements together isn't permitted), there's still all kinds of damage you can do with the UNION operator. So the favored way to get PHP to talk to SQL nowadays is through prepared statements.

BREAKING AND ENTERING

Once you've got DVWA up and running you're probably keen to get started breaking it. That's quite easy to do. We'll spoil the fun a little because

INSTALL THE DVWA IN DOCKER


Not secure | 192.168.0.9:9090/setup.php
DVWA
Home
Instructions
Setup / Reset DB
Brute Force
Command Injection
CSRF
File Inclusion
File Upload
Insecure CAPTCHA
SQL Injection
SQL Injection (Blind)
Weak Session IDs
XSS (DOM)

Database Setup

Click on the 'Create / Reset Database' button below to create or reset your database.
If you get an error make sure you have the correct user credentials in: /var/www/html/

If the database already exists, **it will be cleared and the data will be reset**.
You can also use this to reset the administrator credentials ("**admin // password**") at an

Setup Check

Operating system: ***nix**
Backend database: **MySQL**
PHP version: **7.0.30-0+deb9u1**

Web Server SERVER_NAME: **192.168.0.9**

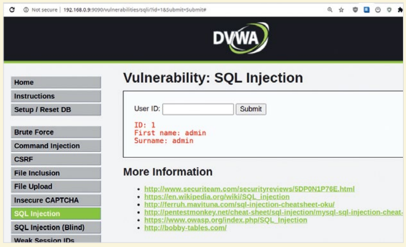
PHP function display_errors: **Disabled**
PHP function safe_mode: Disabled
PHP function allow_url_include: **Disabled**
PHP function allow_url_fopen: Enabled
PHP function magic_quotes_gpc: Disabled

1. RUN THE IMAGE

Use the official instructions to get Docker installed. Then run the image with:

```
$ docker run –rm -it -p 8080:80
vulnerables/web-dvwa
```

In a moment you should find the server running on port 8080 of the host machine. Click the "Create/Reset Database" button to begin the fun.


Not secure | 192.168.0.9:9090/vulnerabilities/sqli/?id=1&Submit=Submit#
DVWA
Home
Instructions
Setup / Reset DB
Brute Force
Command Injection
CSRF
File Inclusion
File Upload
Insecure CAPTCHA
SQL Injection
SQL Injection (Blind)
Weak Session IDs
Submit

Vulnerability: SQL Injection

User ID:

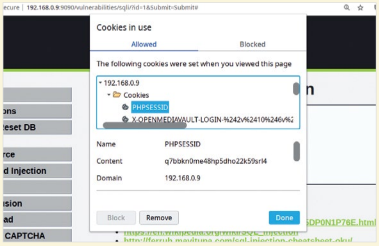
```
ID: 1
First name: admin
Surname: admin
```

More Information

- http://www.securiteam.com/securityreviews/5DP0N1P76E.html
- https://en.wikipedia.org/wiki/SQL_injection
- http://ferruh.mavituna.com/sql-injection-cheatsheet-oku/
- http://pentestmonkey.net/cheat-sheet/sql-injection/mysql-sql-injection-cheat-
- https://www.owasp.org/index.php/SQL_Injection
- http://bobby-tables.com/

2. BEGIN SLEUTHING

Log in with the super-secure combination `admin:password` and go to the SQL Injection page from the menu on the right. This appears to be some kind of user query utility. Try entering "1" into the form. You should see some information about the admin user. See what else you can find out from here.

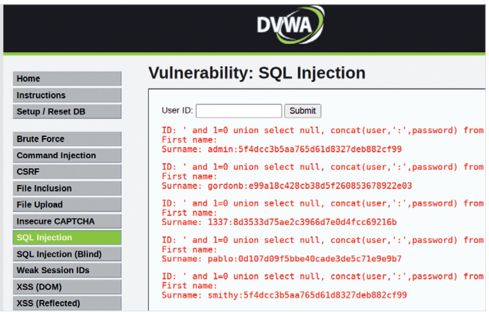

ecure | 192.168.0.9:9090/vulnerabilities/sqli/?id=1&Submit=Submit#
Cookies in use
Allowed
Blocked
192.168.0.9
Cookies
PHPSESSID
X-OPENMEDIAVAULT-LOGIN-%242v%2410%246v%2
Block
Remove
Done

The following cookies were set when you viewed this page

Name PHPSESSID
Content q7bbkn0me48hp5dho22k59srl4
Domain 192.168.0.9

3. STEAL A COOKIE

We're going to attack this web app using SQL later on in the tutorial, but to do that we need the session cookie. Click the site information tab to the left of your browser's URL bar and find the cookies the page has set. There should be one called PHPSESSID, which contains a random string of characters. Copy that down.



Vulnerability: SQL Injection

User ID:

```
ID: ' and 1=0 union select null, concat(user,':',password) from
First name:
Surname: admin:5f4dcc3b5aa765d61d8327deb882cf99

ID: ' and 1=0 union select null, concat(user,':',password) from
First name:
Surname: gordonb:e99a18c428cb38d5f260853678922e03

ID: ' and 1=0 union select null, concat(user,':',password) from
First name:
Surname: 1337:8d3533d75ae2c3966d7e0d4fcc69216b

ID: ' and 1=0 union select null, concat(user,':',password) from
First name:
Surname: pablo:0d107d09f5bbe40cade3de5c71e9e9b7

ID: ' and 1=0 union select null, concat(user,':',password) from
First name:
Surname: smithy:5f4dcc3b5aa765d61d8327deb882cf99
```

SQL injection attacks can be devastating. Look – we just made DVWA cough up usernames and password hashes.

space is short, but try entering the following doozy into the SQL Injection page:

```
' and 1=0 union select null,
concat(user,':',password) from users #
```

As we described above, we've successfully borked the underlying SQL query and tricked the application into coughing up usernames and passwords for the whole team. Oh dear, oh dear. There are some tools that can help find SQL exploits. One of the most popular is sqlmap, which you'll find in Kali's Web Application Analysis menu. In the simplest case, you can probe a form just by passing a URL with something like:

```
$ sqlmap -u http://vulnerable.com/form.php
```

For DVWA, though, because we had to log in to access it we'll need that cookie from step three (below left) if we want sqlmap to see the relevant form. We also need the rather ugly, complete URL from the SQL injection form, which is displayed after you submit it. We'll also cheat a little and turn down DVWA's security via the cookie, otherwise this attack isn't quite so easy. So the proper incantation to sqlmap will look something like:

```
$ sqlmap -u "http://192.168.0.9:9090/
vulnerabilities/sqli/?id=bob&Submit=Submit#"
--dbs --co
okie="PHPSESSID=q7bbkn0me48hp5dho22k59s
rl4; security=low"
```

Hit Return if you're told the URL content is not stable—it's nothing to worry about. You can safely skip the tests for non-MySQL payloads and say no to including additional ones. sqlmap will run through its armory of attacks against the `id` parameter and should eventually spit out this helpful message:

```
GET parameter 'id' is 'Generic UNION query
(NULL) - 1 to 20 columns' injectable
```

as well as two other injections. After that, it will show you three corresponding queries to exploit these vulnerabilities.

Again, sqlmap is for finding bugs in your own applications. Just because you can point it at any form on the web definitely does not mean you should. We know that many readers will have their own Nextcloud installations (inspired perhaps by our Smart Home Office feature), and we trust that you keep these up to date.

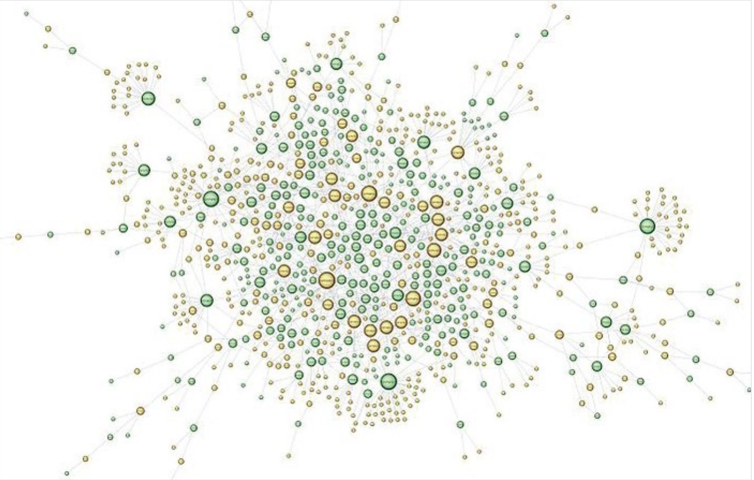
However, just staying updated may not be enough. There's all kinds of room for misconfiguration—not just in Nextcloud itself, but in the underlying LAMP components too. There is some excellent information on hardening your Nextcloud install in the manual, available at http://bit.ly/MPCnextcloud, which covers things like giving PHP access to /dev/urandom (to avoid running out of entropy), and SELinux.

There's also a comprehensive security scan you can run from https://scan.nextcloud.com, which will make sure your instance is watertight. You'll even get a grade at the end. Any web service you're running should use HTTPS. There's no reason not to now that free certificates are available from Let's Encrypt, as well as its excellent Certbot tool for managing them and keeping them up to date. There's plenty of room for misconfiguring HTTPS too, so go to https://ssllabs.com/ssltest and make sure your server gets an A grade.

SOCIAL ENGINEERING

By far the most common attacks involve exploiting human weakness. This might be through a carefully crafted phishing scam, or having a covert agent on the target premises. The compromise of several high-profile Twitter profiles in July was the result of a spear-phishing campaign, where several individuals in the company were targeted until one gave up credentials to account support tools. It wasn't an elegant scheme, but within a few hours followers of the 130 compromised accounts had donated some $117,000 worth of Bitcoin to the scammers. However, they left plenty of tracks and so won't be able to enjoy any of their ill-gotten gains. The mastermind (a teenager from Florida) pleaded guilty to 30 charges in August. Twitter now requires that all employees use physical two-factor authentication (2FA) to access privileged services.

Creating counterfeit banking websites to dupe marks into handing over passwords is a common form of attack. There are plenty of tools for cloning websites, and it's easy to set up a domain name that looks official enough to fool people. Most banks now rely on second factors to log in, but recently cases have been found where the 2FA entry page itself is cloned, so the attacker can relay the credentials to the official page in real time. Always be careful where you click.



Maltego is used to collate data from public sources and find relationships between people, accounts and servers.

© DVWA, WIKIPEDIA

DSHIELD PI HONEYPOT

Use a Raspberry Pi to trick hackers into thinking they've found a juicy target, then study them like ants in a jar

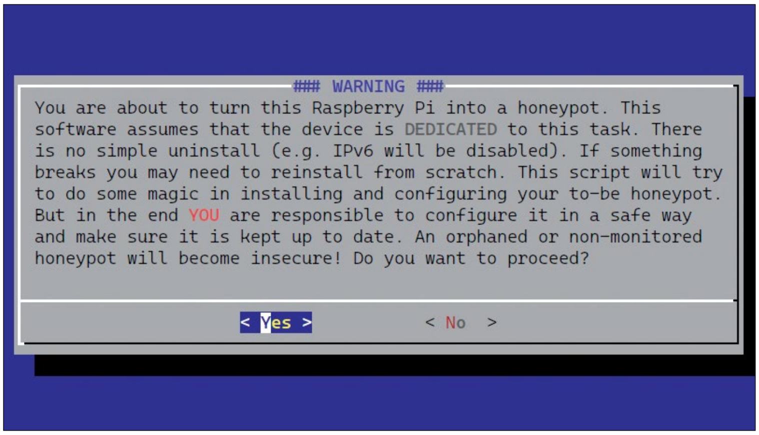
BAITING ATTACKERS TOWARDS your own hardware might not seem a particularly good idea, but if that hardware has nothing of value on it, and is suitably isolated from your other machines, then you can more or less lure them in with impunity. The goal of setting up a honeypot is not to revenge-hack attackers, but rather to detect attacks, and distract those responsible from more valuable targets.

Opening your home network up to the internet isn't something that should be done lightly, though. If the honeypot machine was to be compromised, then it could be used as a staging post for attacking any services running on your network, including your home router. If you were foolish enough to run a honeypot on your desktop PC, then it's possible that an attacker would gain not only root access it, but to all your files, passwords, browser history, and anything else you use it for.

DShield is an easy-to-use honeypot that can be installed anywhere. The Raspberry Pi is ideal for this because it's cheap and the SD card can easily be wiped if something goes wrong. DShield is a distributed intrusion-detection system created by the Internet Storm Center (ISC). In its own words, "DShield collects data about malicious activity from across the internet. This data is catalogued and summarized and can be used to discover trends in activity, confirm widespread attacks, or assist in preparing better firewall rules." So setting up a Pi-based DShield sensor, as they're termed, will help the security of the internet in some small way. DShield uses Cowrie, which runs dummy SSH, web, and other services to tempt attackers and gather data about what they're trying to do.

GET STARTED WITH DSHIELD

Before you can use it you'll need to join the project by setting up an account at https://dshield.org.



```
### WARNING ###
You are about to turn this Raspberry Pi into a honeypot. This
software assumes that the device is DEDICATED to this task. There
is no simple uninstall (e.g. IPv6 will be disabled). If something
breaks you may need to reinstall from scratch. This script will try
to do some magic in installing and configuring your to-be honeypot.
But in the end YOU are responsible to configure it in a safe way
and make sure it is kept up to date. An orphaned or non-monitored
honeypot will become insecure! Do you want to proceed?

            < Yes >             < No  >
```

Please do heed this warning and understand the horrors that your Pi may be exposed to in the DMZ.

DShield can be installed on any Linux distribution via Git, and some tweaks are necessary to install it on the Pi. Check the project's Github at https://github.com/DShield-ISC/dshield if our instructions here fail you. Before we get to DShield, though, we need to ensure that our Pi is correctly set-up. We'd recommend starting with a fresh installation of Raspberry Pi OS Lite. If you don't have a monitor and keyboard for your Pi to hand, then you can activate the SSH server and interact with it that way by placing an empty file called ssh on the SD card's boot partition:

```
$ touch /media/user/boot/ssh
```

After that, you can use Nmap to help you find the Pi's IP address on your local network with something like:

```
$ sudo nmap -p22 –open 192.168.0.*
```

which will search the network for devices running on the default SSH port. Your Pi should be easy to spot because it'll show up as a Raspberry Pi Foundation device. Log in (either by SSH or physically) using the default pi:raspberry credentials.

Ensure the date is set correctly by running:

```
$ date
```

If it isn't, then you'll end up generating invalid SSL certificates, and various other things will fail mysteriously. It's also worth running `raspi-config` for the purposes of changing the default password, making SSH permanently active, ensuring the correct timezone is set, and expanding the filesystem to use the entire SD card. Before you reboot, it's worth upgrading everything (which will take some time so a cup of coffee is recommended), and installing Git.

```
$ sudo apt update
$ sudo apt upgrade
$ sudo apt install git
$ sudo reboot
```

Reconnect to your Pi and clone the DShield repository:

```
$ git clone https://github.com/DShield-ISC/dshield.git
```

Then run the installation script:

```
$ cd dshield/bin
$ sudo ./install.sh
```

The script will install lots of packages (you probably have time for another cup of coffee during this phase) and then give you one last chance to bail out. Do heed this warning: if you proceed it will ask you for your email address and API key, which you set up earlier. The key is in the My Account section on the website. Next, you'll be asked for a network interface (wired is recommended) and which networks and IPs to trust. It figures these out based on machines currently connected to the Pi. As part of the bait, a bogus SSH instance will take over the default port, so after this step you'll need to SSH to port 12222 to administer DShield. Finally, some Python packages will be installed via Pip, and a certificate will be generated (it's okay to accept all the defaults here). And by now you've definitely earned that third cup of coffee.

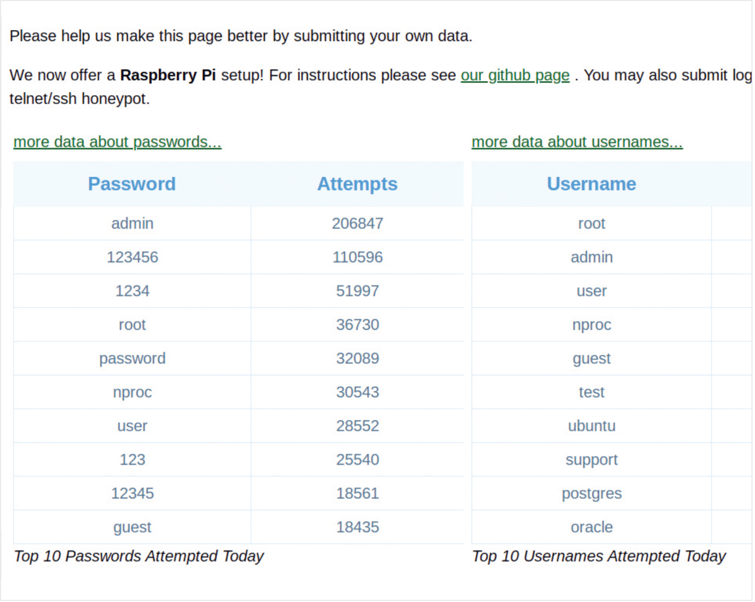
Reboot the Pi again and SSH to the new admin port, and check all is well with DShield:

```
$ ssh -p 12222 pi@192.168.x.x
$ cd dshield/bin
$ sudo ./status.sh
```

You should see an error saying that the webserver is not exposed. To attract bots and humans from outside your network, you need to tell your home router to forward incoming connection attempts to the Pi. You may already have some forwarded ports set up, either manually or via uPNP. Each router is different, but most have a DMZ (demilitarized zone) option, which will forward all traffic that wouldn't be forwarded elsewhere. You could also forward only selected ports, but the goal of DShield is to capture as much traffic as possible, so this isn't really recommended.

To see connection attempts in real time, run:

```
$ tail -f /var/log/dshield.log
```



Please help us make this page better by submitting your own data.

We now offer a **Raspberry Pi** setup! For instructions please see our github page . You may also submit log
telnet/ssh honeypot.

more data about passwords...

Password	Attempts
admin	206847
123456	110596
1234	51997
root	36730
password	32089
nproc	30543
user	28552
123	25540
12345	18561
guest	18435

Top 10 Passwords Attempted Today

more data about usernames...

Username
root
admin
user
nproc
guest
test
ubuntu
support
postgres
oracle

Top 10 Usernames Attempted Today

After a few days spent using DShield, you'll see how unimaginative the bots are with their feeble password attempts.

FOLLOW THE ACTION

Besides logging usernames and passwords for any attempts to login, Cowrie—another honeypot—will also fake a command shell to several common usernames and passwords and capture the whole session. Any URLs requested from the webserver are also collected. Follow Cowrie activity with:

```
$ tail -f /srv/cowrie/var/log/cowrie/cowrie.log
```

If you want to play around in Cowrie's faux shell, just SSH to your router's external IP address (Cowrie doesn't listen on the internal address) using the credentials `root:password`. Lots of standard shell commands will appear to work correctly, but if you try something like `rm -rf` on the root directory you'll quickly see that it's all trickery. Everything you type is logged, and you can `grep` it out of the logs (after first logging out of Cowrie's deceptive shell) with:

```
$ grep CMD /sr v/cowrie/var/log/cowrie/cowrie.log
```

It's important to not take these personally, and remember that most of these will be automated scans and bots. DShield is configured to send logs every half hour via a cron job. After that time your data will be visible from the My Account menu at the DShield portal.

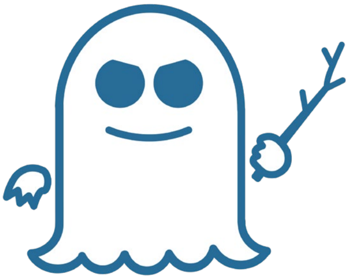
Cowrie is designed to mimic services, but also to be very simple behind the scenes. This reduces the possibility of it actually falling to a vulnerability at some stage. After a few hours' use, our logs started to show a few Python tracebacks resulting from Cowrie crashing out. This is in general nothing to worry about. In theory that's not meant to happen, and those tracebacks are sent to the project to stop them happening in future. ⏻

ROOTED ROUTERS AND PRUDENT USERS

Most of what we've covered here will be more of interest to those wanting to defend their services than to home users. It's hard to give general advice for protecting your home network. We've always told users to keep their software updated and to be wary of emails from princes needing somewhere to stash their fortunes. And in general that advice goes a long way—those princes aren't real, and popular applications are patched quickly. The Linux kernel has second-to-none security processes, even in the face of Spectre and Meltdown vulnerabilities that will be here for a long time.

We put a lot of trust in our home routers, though, and perhaps that's misplaced. Imagine if all the machines on your network were subject to the same probing and bothering that our honeypot endured over the past few days.

In 2018 a strain of malware dubbed VPNFilter was found to have infected half a million home routers worldwide. While no damage was ever recorded from this attack, the malware had the ability to siphon off traffic, collect personal information, or brick the host router entirely. A domain used as a command and control (CnC) server was seized by the FBI soon after it was discovered, paralysing it. As IPv6 gains adoption, and as more IoT devices are exposed to the internet without appropriate security, this kind of attack will become more prevalent.



Speculative execution bugs are going to haunt us for years to come. WoooHOOO!

© DSHIELD

KEYBOARD WORKSHOP

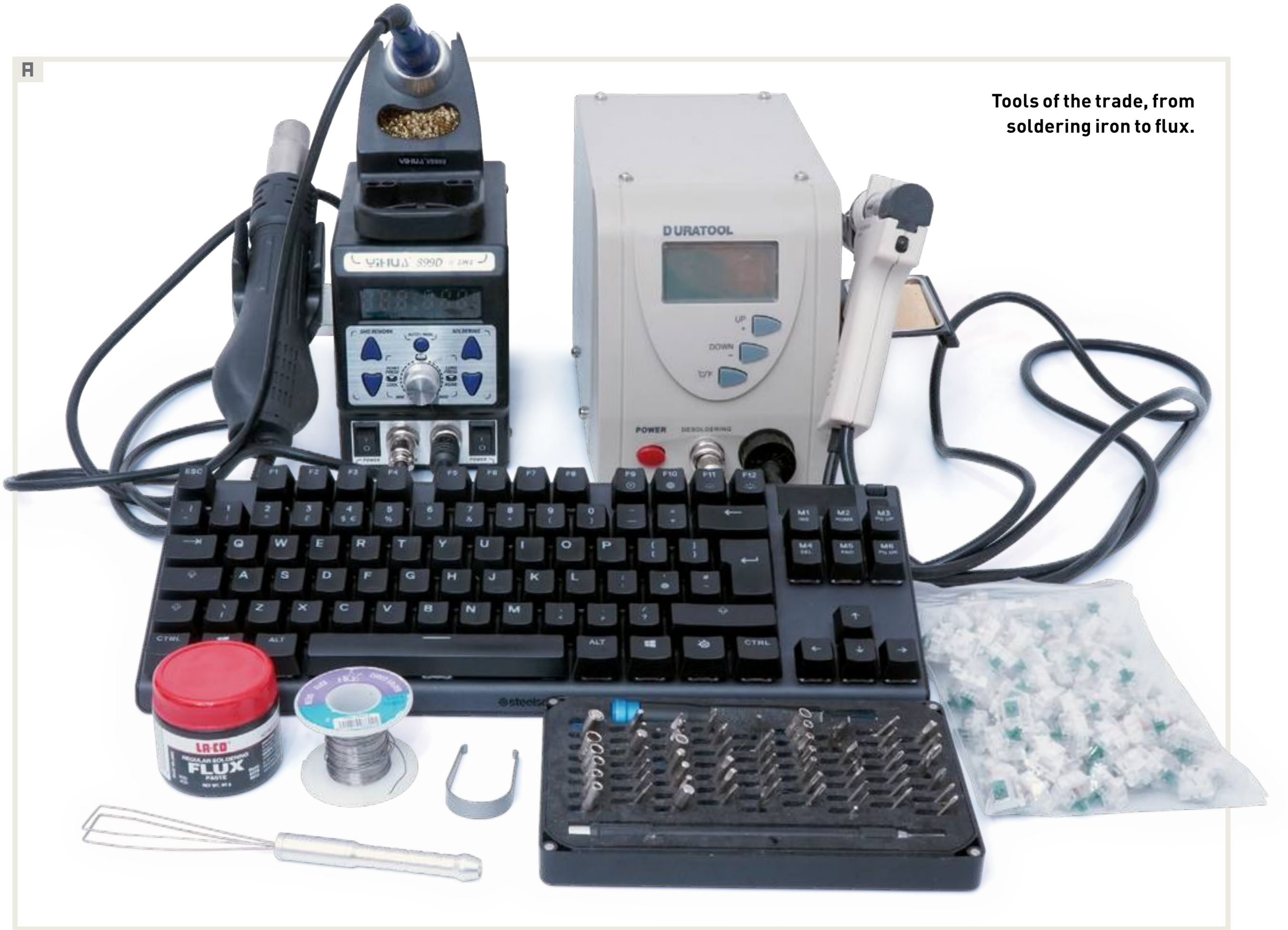
THE GREAT KEYBOARD SWITCH SWAP

We take a look at the techniques and tools needed to swap out an aftermarket keyboard's switches for something customized

This issue, we've taken a look at the SteelSeries Apex 7 TKL keyboard (page 87). It is actually one of the best off-the-shelf keyboards we've reviewed in a long time. It scored a 9 and earned our Kick-Ass award. That is realistically the highest score any product will get at *Maximum PC*, as nothing is ever perfect: even if it ticked every single one of our boxes, it's just not going to be the right fit for everyone—therefore, it can't ever be a 10. There's always something that can be improved upon.

The Apex 7 we received for review had Cherry MX Brown switches. These switches are a favorite for a lot of folk, but as professional writers working in tech, we often like heavier, tactile switches, and the Browns in the Apex 7 just don't tickle our fancy. Now, the problem we have here is that the Apex 7 is not technically "hot swappable", but we love the keyboard so much that we want to make it our own. So, it's time to see if we can do a switch swap.

You can change the switches on almost any keyboard. Sure, hot-swappable boards are far easier to do this with, and if you know that you want to swap switches often, we advise buying one of these (see, the Apex 7 isn't perfect for everyone). However, on boards that are hard-soldered, you can usually change them fairly easily with just a modicum of skill and a few handy tools. Let's get to it, shall we? –DAVE ALCOCK



Tools of the trade, from soldering iron to flux.

Starting Out

This time around, we want to use Gateron Green switches. These are pretty much on par with Cherry MX Green switches, but we are using these ones instead of the Cherry counterpart because they're compatible with the LEDs that SteelSeries uses in its boards. We would have loved to use some other switches, such as Sherbets or Holy Pandas or something else that's equally fun, but alas, we again didn't have any that were compatible with the LEDs.

Before we move onto the tools you'll need, there is one thing to remember. When doing any modifications like this, you will void your warranty entirely, and there is absolutely a chance you could render your keyboard unusable. So if you are unsure in any way, just don't do it.

Tools of the Trade

The main thing you will need is a soldering iron. Now, you can get these for as little as $10 from Home Depot or similar hardware stores, but it is important that your soldering iron can get to the temperature needed to melt the solder that the keyboard manufacturer uses. We've seen solder stay strong at 850 F, so we recommend a soldering station.

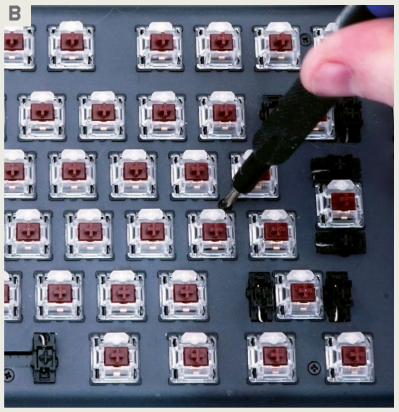
Something that isn't needed as much, but is certainly advisable to have, is a desoldering station. When desoldering with a standard soldering iron, it is extremely easy to damage the solder pads around the switch and LEDs. You can use soldering pumps or solder wick, but having tried all of the options, a reasonably cheap station is so much better for the job—especially if you are going to be doing multiple keyboards, or you have a use for it elsewhere in your life.

You will also need some solder and some flux [**Image A**]. People often disregard flux, but it makes soldering much easier. It helps when cleaning the contacts, as well as breaking the surface tension of the molten solder so that it doesn't just stay a molten blob. If you don't want to shell out for the flux, then at a pinch you can use petroleum jelly. For the solder, we usually use some lead-free 0.3mm solder, but really you can use whatever you can get.

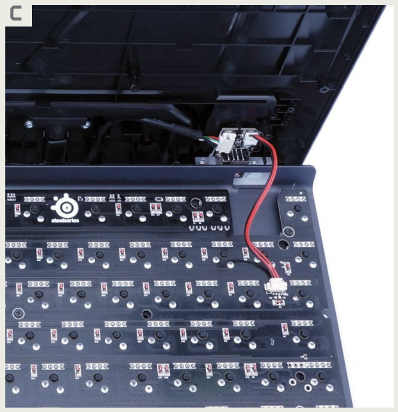
It is also advisable to get a switch puller and a keycap puller. These are not 100-percent needed, but they do make the job a lot easier. If you don't want to buy these, then a micro-screwdriver kit can suffice. You will need to have the screwdriver kit anyway.

PCB Removal

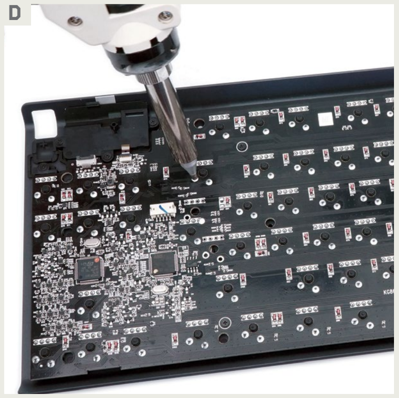
The first job is to access the PCB so that you can get at the switches and LEDs [**Image B**]. This differs from keyboard to keyboard. Some keyboards have multiple plates that need to be removed, while some have covers that are tricky to take apart. Sometimes the screws are hidden behind the feet of the keyboard, and sometimes keyboards are horribly push-fitted together with tabs instead of screws. Having said that, some are easy to disassemble. In our case, the Apex 7 TKL is one of the easy ones. All the screws are accessible without having to remove stickers or feet. To see the screws, simply remove the keycaps. If you are not too proficient with keyboards, take a picture of the layout so that you can put them all back in place again afterwards.



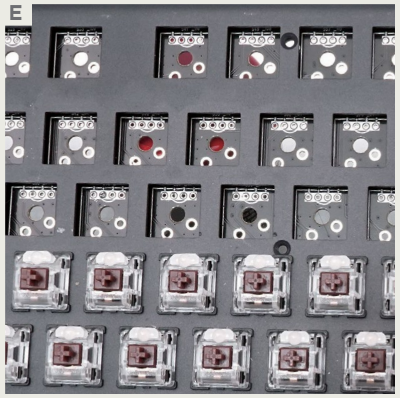
Remove the keycaps and screws



Be careful of the wires!



Desoldering guns are useful but not essential.



Remove the switches, but be careful not to damage sockets.

While removing the case, it is important that you don't damage any of the ribbon cables or wires, so remove it carefully [**Image C**]. Most of the cables are simple to remove and just require you to pull the connector from the clips, but ribbon cables have a few different styles—some clip down and some slide forward. Don't force the movement on ribbon cable clips as they can be delicate.

The Desoldering Begins

Once you have access to the rear of the PCB you can start desoldering the switches and LEDs [**Image D**]. In the Apex 7 TKL, SteelSeries uses four pole LEDs and standard Cherry MX-style switches. This means that there are four pins per switch to remove, and 86 switches, so if we've counted on our fingers correctly, that makes it 344 desoldering points.

This is why we suggest using a desoldering gun. This works by heating up the solder until it is in liquid form, then vacuuming it up into the glass chamber. Without one, desoldering is far trickier and more time-consuming.

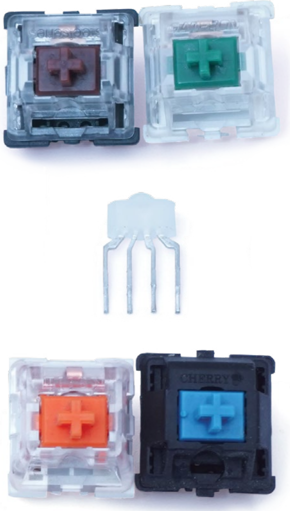
If you don't wish to shell out on a desoldering station, you can use a soldering iron to heat the solder, then use a solder pump to remove it, or use a soldering wick to absorb it. Use only the heat that you need to make the solder liquid—too much heat can burn the pads from the PCB, and you will render the keyboard useless, unless you can trace the PCB and do some cable patches (which we won't go through today as that is quite an extensive topic). So be careful.

Switch Removal

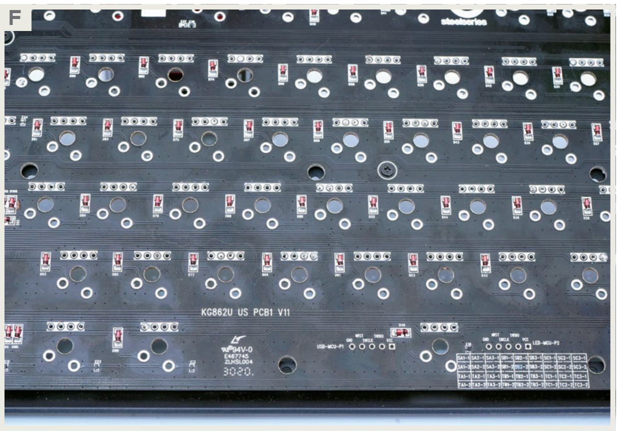
Once the solder is removed from around the pins, it's time to remove the switch. This is where a switch puller makes the job a lot easier [**Image E**]. The puller grips the switch in such a way that it compresses the latches that hold it in place, making the switch easier to remove. If you don't have a switch puller you can push the switch from the rear of the PCB and get it out. Removing the switch is one of the most dangerous parts of the job. The socket can be pulled/pushed out, or damage can occur to the soldering pads. To stop this from happening, make sure

CHOOSING SWITCHES

Choosing the correct switch is very important when you are customizing your board, as there are multiple options. You have two main types of mount—PCB mount, or plate mount. PCB mount has two extra prongs that go into the PCB, while plate mount doesn't have these. We usually buy PCB mount, as you can cut the prongs off to make them plate mount. There are also different pinouts and shapes too—for example, Alp switches will not fit a keyboard that is made for Cherry MX-style switches. There are also different housings for switches. As you can see in the image, (*below*), the LED in the middle will fit the slot on the top two switches, but it won't fit the slot for the two switches at the bottom, as they are just for two-legged LEDs. There are also switches for SMD LEDs. Although it might sound confusing, a small bit of research goes a long way when it comes to getting the correct switches.

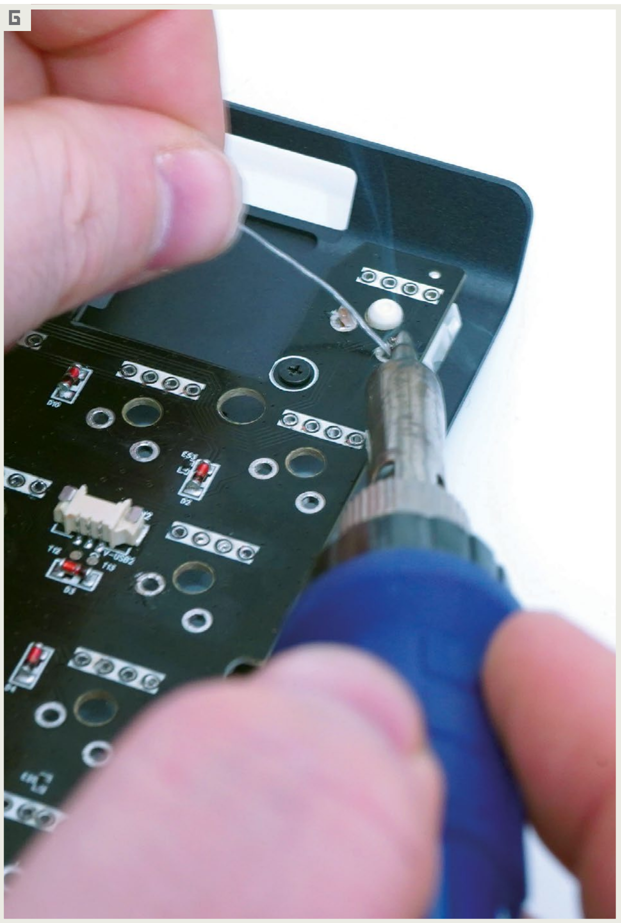


F



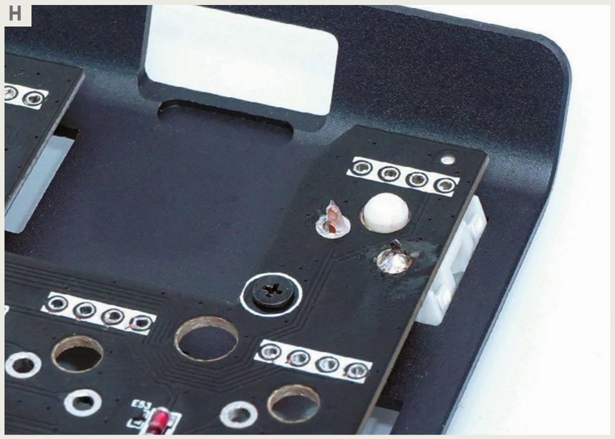
So clean, so pretty, the switches are gone!

G



Solder using flux; seriously, it makes things so much easier.

H



A little goes a long way.

that the solder is completely removed from the pins—if they're connected in any way you could have problems.

When all the switches have been removed, the PCB should look like this [**Image F**]. There should be no remaining solder and no damaged pads or sockets. If there is stubborn solder, such as in the small holes on the LEDs, try and remove it if possible, but if you can't, then make sure you heat it when you're soldering switches in place later. You don't want to create any gaps between the two sets of solder.

New Switch Time

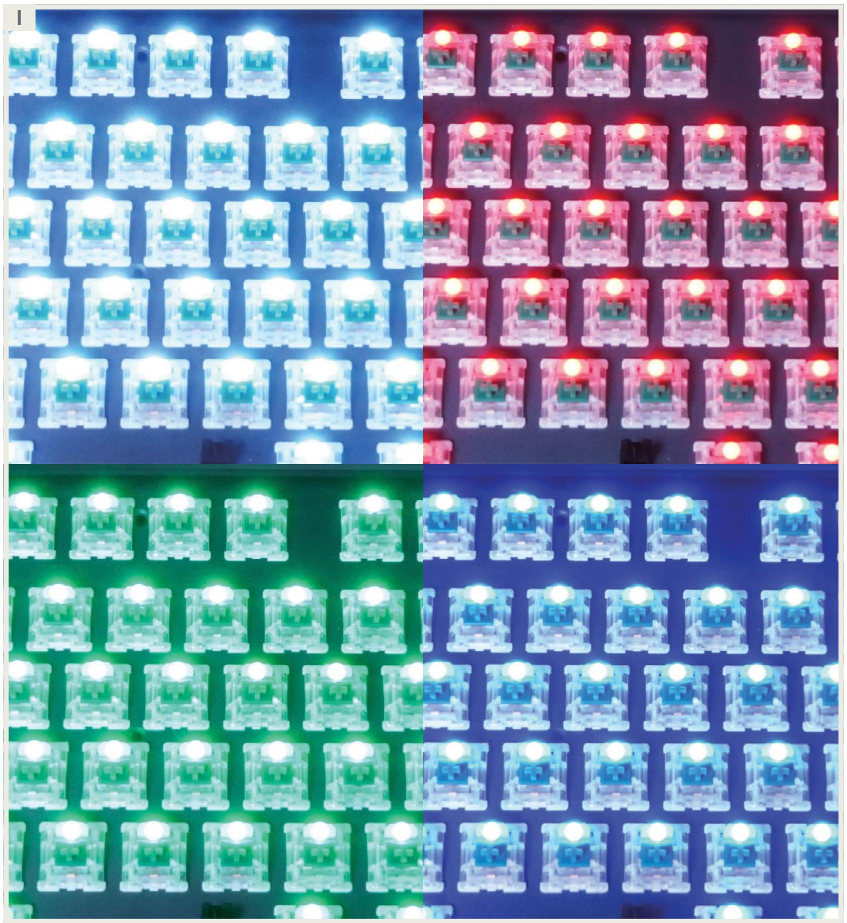
Now it's time to push in the new switches and LEDs. The switch will usually go in first, then the LED afterwards. We like to work methodically and do all the switches, then all the LEDs [**Image G**]. Once the switch is pushed through, dab the pin and the pad with a little bit of flux. You don't have to put much on at all—just a smidgen will make the soldering process a whole lot easier. Next, heat the solder and the pin at the same time, and because of the flux and the similar temps, the solder will just run down the pin and bead around the soldering pad. It sounds simple, but getting the knack of it can take a few attempts. You don't need to put too much solder on either—all it is doing is connecting the pins to the pads, so you don't need a mountain of the stuff.

Here you can see how the solder and flux should look [**Image H**]: the left pin just has the flux on, and the right pin has been soldered. When the flux melts it leaves a residue, so clean the bulk of this off with a clean, soft-bristle paint brush, and then clean the remaining bits with some isopropyl alcohol. There are some "no clean" flux types on the market, but for the few minutes it takes to clean up, it is not worth leaving it on. Flux can cause corrosion over time, so it's not worth it.

Workarounds

Once you've soldered all the switches and LEDs, you can test it all before you put the case back on. Test every switch, and try multiple colors of RGB lighting [**Image I**]. It's good practice to set all the LEDs to white. This will usually show up any that are not performing correctly, as white uses the three colors of the RGB LED. If it can't produce the green, the LED will look purple instead. If it can't create the blue, you will get yellow, and if it can't produce the red it will be cyan. If you get a color other than white, check that the pins are soldered correctly. You can work out which pin is failing by understanding the color that is being produced. However, it takes more brain power than just checking all four pins.

If a switch doesn't work, again, check the solder. If there is a pad damaged, particularly for a switch, all is not lost. Switches are laid out in columns and rows, and keyboards know which switch is being pressed like it is a game of Battleship. This means you can often bridge a damaged switch, and even LEDs, with another one somewhere else on the same row or column—you just have to determine the path of the wire. The easiest way to do this is just shorting out the switch with partnering switches and seeing if it works or not. Once you've figured out which row/column the switch is partnered to, you can solder a small wire to bridge the gap. In



Testing the RGB now saves you from having to strip the casing again.

the future, when we have more time we can show this in more detail, but there's already some information on this process out there on the internet. The main thing is to not panic if something doesn't work.

Work Complete

Once all your switches are working and your LEDs are acting as they should, you can then put the ribbon cables and wires back and put the board back together. That's it! You just did a complete switch change! Yay! Okay, it does seem daunting, and we should be cautious, as saying it is easy might prompt everyone to start ripping switches off their boards, but it isn't too hard. The main thing is to take your time, and if something feels wrong, it probably is. If a switch is very stubborn when you are trying to remove it, don't force it out. Treat it nice.

So, how does the SteelSeries Apex 7 feel after the switch change? Glorious. We have no idea why Green switches are not more common in keyboards—if you like Blue switches, think of them, but heavier. For writers it just gives you a satisfying feeling, with feedback on every button you press, and enables us to rest our hands on the keyboard while we try and remember if it is their, there, or they're.

It would have been fantastic to be able to use some other kinds of switch, and if we knew before it arrived that we were going to love the Apex 7, we would have ordered some in specifically for it. SteelSeries caught us off guard with this board, however—we didn't expect to like it and the software as much as we did, and we wanted to put it into service as quickly as possible. Maybe in the future we will switch out all the switches again and put something a little bit more exotic in.

The keyboard is almost perfect now, although there is one other change that might be on the horizon—swapping the hardwired cable for a removable one. We're not quite sure how to do this while keeping it all clean and tidy, especially since there is a passthrough cable to think about as well, but it can't be that hard, right? ⏻

HOT SWAPPABLE BOARDS

Changing switches doesn't have to be a time-consuming money pit. You can buy hot-swappable boards, and even hot-swappable sockets that can be inserted into standard PCBs. These used to be quite hard to get hold of, but brands are slowly starting to see the benefits. The Drop CTRL and ALT are fantastic examples of hot-swappable boards, but they are not really mainstream in terms of brand. You may have heard of Glorious, the makers of the insanely popular Model O and D mouse. Well, the company also has the GMMK that we reviewed in November 2020 (vol. 25, no.11), which is great and—you guessed it—features hot-swappable switches. Even Logitech, one of the biggest players in the peripheral game, has a board with hot-swappable switches, the G Pro X. These boards all negate the need for soldering or desoldering, and they enable you to just buy switch packs that are compatible, and change the feel and typing experience in minutes.

Esc
Tab
Caps
Shift
Ctrl
Alt

Hot-swappable boards are the quick way to get custom switches.

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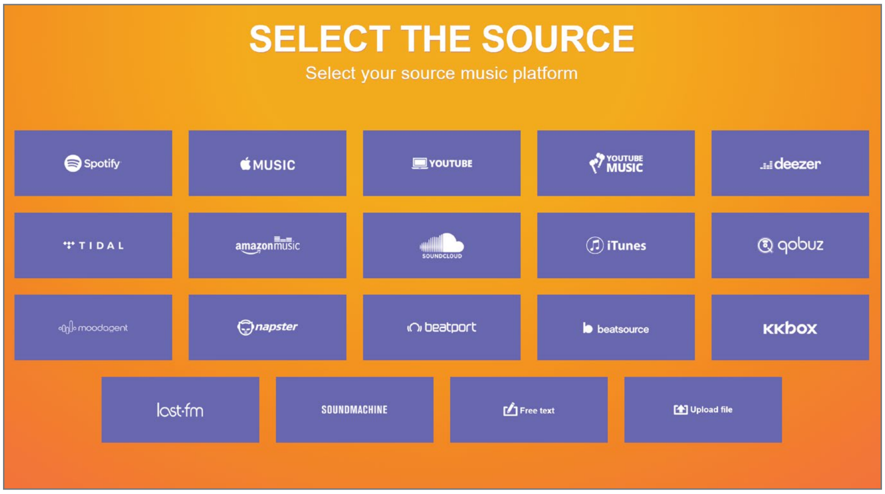
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



SELECT THE SOURCE

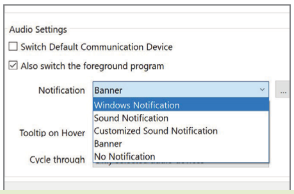
Select your source music platform

TUNE MY MUSIC

Thinking of switching music-streaming services, but the huge headache of transferring your beloved playlists is clouding your vision? Well put your worries aside for one moment while we show you this little gem. TuneMyMusic is a website that lets you put your feet up and relax as it does all the hard work for you. It's simple, effective, and straight to the point. www.tunemymusic.com

MAKE – USE – CREATE

62
How to use Photoshop part one: an introduction



Audio Settings
☐ Switch Default Communication Device
☑ Also switch the foreground program
Notification: Banner
Windows Notification
Sound Notification
Customized Sound Notification
Banner
No Notification
Tooltip on Hover
Cycle through

67
Switch audio output with SoundSwitch

68
Take a look back at Microsoft MSX architecture

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SAM LEWIS
STAFF WRITER

PLAYER 2 HAS ENTERED

Well hello! I'm Sam, a fresh tech-head looking to delve deeper into this ever-advancing industry. You'll be seeing my face a little bit more often around here from now on. Scary right? Graphic design has always been my calling, but with 2020 being the whirlwind it was I now find myself changing career and writing here at *Maximum PC*. I have been doing graphics since I was a 12-year-old, so for me this is an exciting new adventure.

Luckily I've always been surrounded by tech, so the switch-over is one I'm thrilled about. Talking of the switch, the team has blessed me with a kick-ass PC paired with a gorgeous MSI Prestige PS341WU monitor. It doesn't take a tech wiz to realize that's one hell of an upgrade from my 2014 MacBook. Productivity is a breeze on this behemoth, so I can't wait to get going.

Audio tech is a massive part of my life. Ever since I was lucky enough to get my first iPod Nano back in 2006, I was hooked. Zak is well aware of this, so let's just say I've got some interesting pieces for you all around the corner. Another element of tech that has always caught my attention is gaming. However, I'll admit that I am a self-diagnosed casual gamer. This role will hopefully allow me to break that spell, and I can dip my toes into the world beyond 30fps.

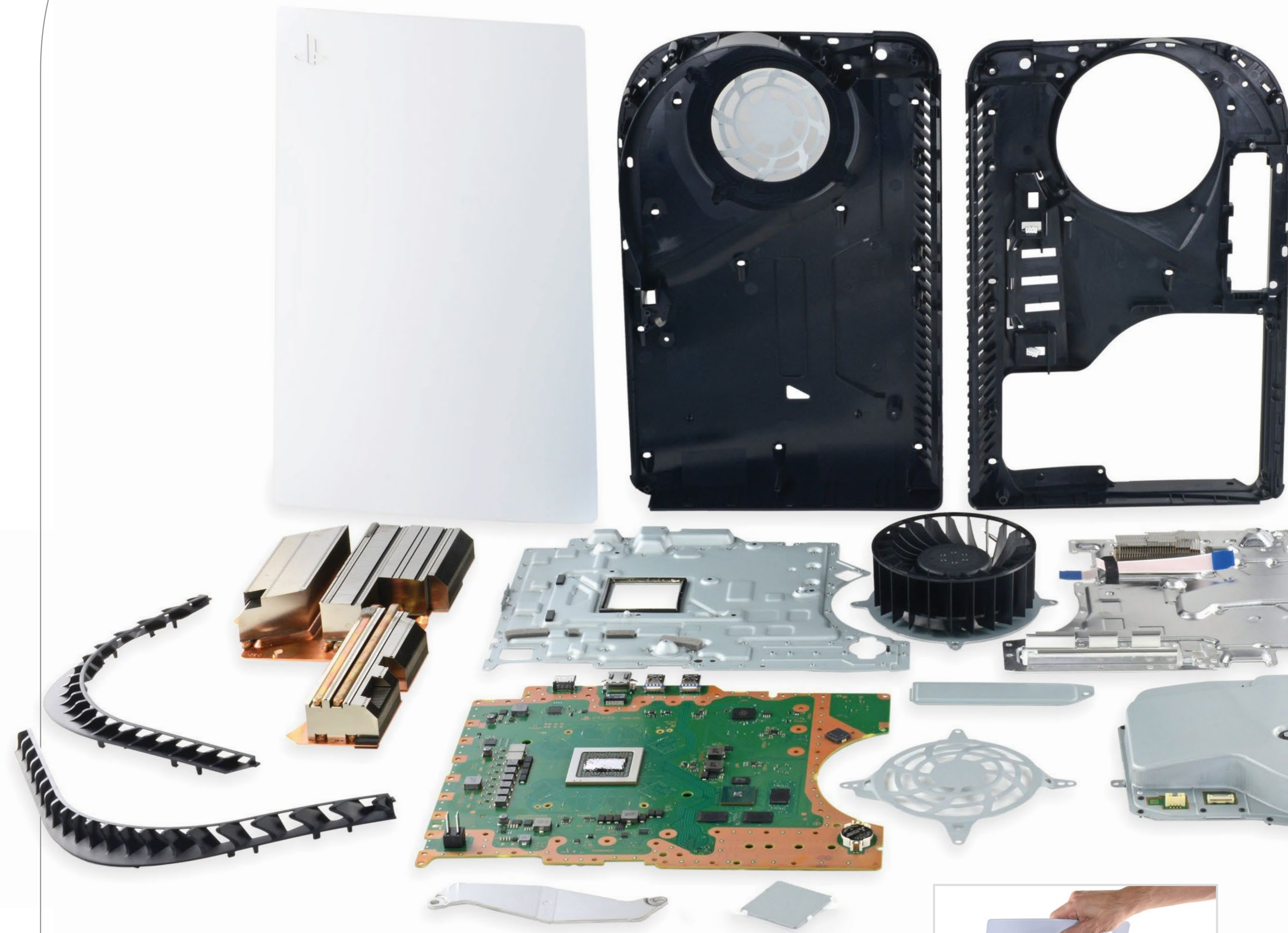
↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

PlayStation 5



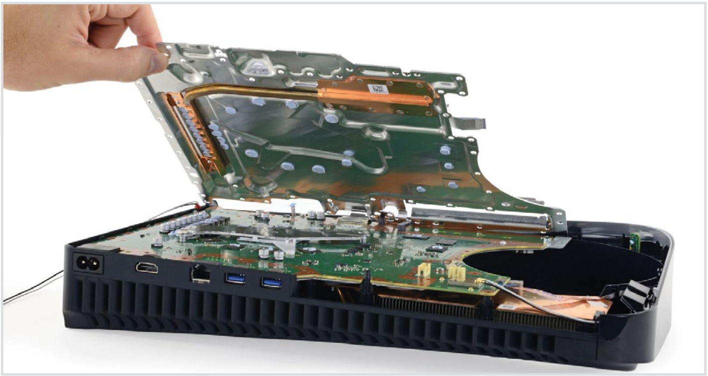
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

***Right*: It doesn't take a rocket scientist to pop open this next-gen console.**

***Far right*: Did somebody tell Sony that we love screws? Because this steel plate is secured with a ton of screws. Um, thanks!**

Sony includes a thoughtfully designed stand. With just a bit of fiddling, it allows the PS5 to either pose vertically or lie gracefully on its side.



BACKGROUND

We finally put down our PS5 long enough to do a proper teardown. We really want this thing to work again when we're done. We're not going to hold back, though. Here we go.

MAJOR TECH SPECS

- AMD custom 8-core / 16-thread 3.5GHz Zen 2 CPU
- AMD custom RDNA 2 GPU (2,230 MHz with 36 compute units)
- 6GB RAM, 128GB storage (256 and 512GB configs available)
- 16GB GDDR6 RAM
- 825GB of SSD storage (plus an M.2 SSD expansion slot)
- HDMI 2.1 connectivity, support for 8K video at 60Hz, or 4K at 120Hz

KEY FINDINGS

- The last fully fledged, whole-number PlayStation launch was back in 2013, so we're pretty excited. You may have heard that the PS5 is big. This thing towers over its predecessor—not to mention its competition. Around the back, the PS5 shows off its ports: two USB-A 3.0, LAN, HDMI 2.1, and two-pin power. Add those to the duo of USB ports on the front (one Type A, one Type C), and you've got a reasonably well-connected console.

- The opening procedure is actually quite human-friendly. Both white panels pop off with a gentle lift-and-slide motion—allowing immediate access to the M.2 SSD expansion slot, the fan, and... vacuumable dust ports. When it comes to easy maintenance of your console's cooling hardware, we're big fans. But to go any farther, we need a T8 Torx Security driver. (Why does your PS5's fan need security screws?) The M.2 storage expansion bay is very accessible. Remove one Phillips screw and a metal shield, and you're ready for upgrades. That's thoughtful, since the built-in storage is worryingly limited.

- As we remove the first half of the black plastic shell, we're greeted by the optical drive. The slender optical drive doesn't put up much of a fight coming out—which would be good for potential replacements, until you actually try a replacement. Underneath there's a heat pipe for cooling a row of VRMs, connected to a baby fin stack. Looks like we're seeing the back of the main board—all the serious cooling hardware is mounted down below. We may be approaching a point of no return, but let's un-mount the hardware and flip the board out.

- Here's a look at the silicon that powers the PS5: Sony Interactive Entertainment Inc./AMD CXD90060GG 8-Core CPU w/ GPU, Sony Interactive Entertainment Inc. CXD90062GG SSD Controller, SK Hynix H5AN4G8NBJR-UHC DDR4 SDRAM Memory —512 MB, 6x (three per side) Kioxia/Toshiba Memory TH58LJT0T24BA4M BiCS flash memory (likely) and Micron MT61K512M32KPA-14:B 2 GB GDDR6 SGRAM.

- Underneath metal shield number two is a massive heatsink and the power supply. Since heat rises, it makes sense that this heatsink is designed to move heat upward through all those heat pipes. All the while, the heat radiating through the silver fin stacks is blown away by the fan.

- PlayStation 5 Repairability Score: 7 out of 10 (10 is easiest to repair). Outer covers can be replaced without tools. Many components are modular, and disassembly is straightforward. Vacuumable dust ports makes de-dusting easier. The main storage is integrated to the motherboard, but expansion should be easy (once enabled by Sony) with off-the-shelf M.2 SSDs. The optical drive is a cinch to replace, but cannot be easily swapped thanks to software locks. Sealed-in liquid metal TIM could be challenging to replace during service. The use of security screws hinders repairs.

How To Use Photoshop Part 1

YOU'LL NEED THIS

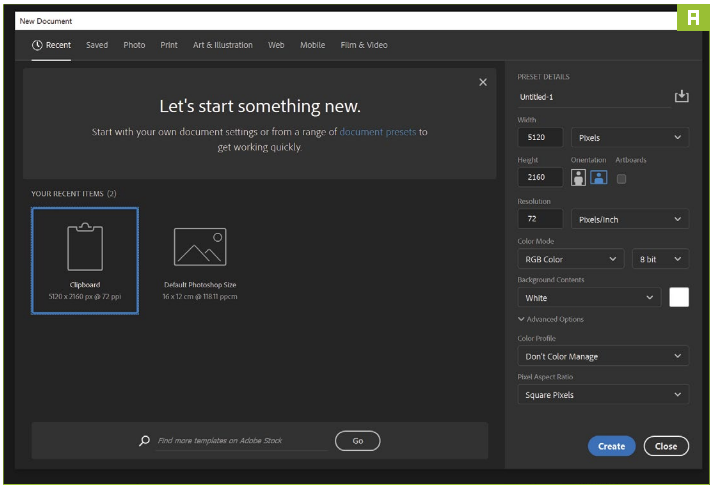
ADOBE PHOTOSHOP CC 2018 ONWARDS
Windows 10 (64-bit) version 1809 or later.

To view compatibility visit: https://helpx.adobe.com/photoshop/system-requirements.html

PHOTOSHOP: YOU'VE ALL SEEN IT, you've all heard of it, but there is a lot more to know about it than you first realize. In this series, we'll break down different ways you can take advantage of Photoshop, to squeeze every cent's worth from the high monthly cost of the Adobe CC suite.

So, what exactly is this software? In simple terms, it's the world's leading photo-editing application. It's a tool used by millions of graphic designers, artists, photographers, and people who just want to goof around putting their buddy's face onto anything their heart desires. Use your imagination there. American brothers Thomas and John Knoll developed Photoshop in 1987. Adobe Systems Incorporated then bought the distribution license in 1988. Little did they know that their beautiful creation, which probably caused them years of brain bashing, was to be used to plaster memes all across the internet.

Anyway, less of that. In this series we are stripping things right back to the beginning, getting familiar with this software, building confidence, and setting the building blocks to Photoshop heaven. Let's have some fun with it. Photoshop can be used simply for re-touching images,and adding effects, all the way to creating one-of-a-kind pieces of art. There are many ways to use this, and hopefully you'll learn a little here. **–SAM LEWIS**


A
New Document
Recent
Saved
Photo
Print
Art & Illustration
Web
Mobile
Film & Video
Find more templates on Adobe Stock
Go
Create
Close

Let's start something new.

Start with your own document settings or from a range of document presets to get working quickly.

YOUR RECENT ITEMS (2)

Clipboard
5120 x 2160 px @ 72 ppi

Default Photoshop Size
16 x 12 cm @ 118.11 ppcm

PRESET DETAILS
Untitled-1
Width: 5120 Pixels
Height: 2160
Orientation
Artboards ☐
Resolution: 72 Pixels/Inch
Color Mode: RGB Color 8 bit
Background Contents: White
Advanced Options
Color Profile: Don't Color Manage
Pixel Aspect Ratio: Square Pixels

1 OPEN AND CUSTOMIZE

Let's get right into it. When opening Photoshop you are given the option to create a new file or open an existing one. If you're familiar with other Adobe products this will look similar to a lot of them. If not, you'll get to know it like the back of your hand. You can create a canvas of any size you desire by clicking "Create new" at the start [**Image A**]. When creating from new you get the choice of canvas size, preset sizes, orientation, color mode, and background. If you decide to alter your canvas size later, go to "Image → Canvas size" and change it to whatever suits.

» After opening a file or creating a new one you will be taken to the canvas. The canvas is what you'll be working on. Like pretty much all programs, along the top you have the menu bar, containing File, Edit, Image, Layer, Type, Select, Filter, 3D, View, Plugins, Window, and Help.

» One of the most convenient things about Adobe software is that it is heavily customizable. If you think you can improve the standard layout then you can make it yours. The left side of the screen is where you can find the tools—any tool with an arrow on the bottom-right corner can be long-pressed to reveal more tool options. To the right, you'll find the panels: Layers, Paths, Channels, Swatches, etc. You can add and remove panels to best suit your needs. Photoshop is designed to be altered with the creator in mind.

2 IMPORT AN IMAGE

To get used to an array of tools and familiarize yourself with the software, next we'll go through how to remove an item from an image, or "Photoshop it out"—probably the most Photoshop thing you can do with Photoshop, right? So, have you taken a picturesque landscape shot of a jaw-droppingly beautiful beach, but a pesky bird has flown into the shot? How convenient, say no more. First things first, we need to import the image.

» There are a few ways to do this. You can find the image, right-click it, then "Open with → Adobe Photoshop CC", or click "Open" on the side of the welcome page, go to File → Open, or even drag and drop an image in.

» Once the image is imported, you have to think about where the image is going. If you're intending on using the image for print then the color space should be CMYK (cyan, magenta, yellow, and key). This is a printing process. In basic terms printers use these four colors to make all colors it needs, so using CMYK will mean that when you image is printed it will look as similar to

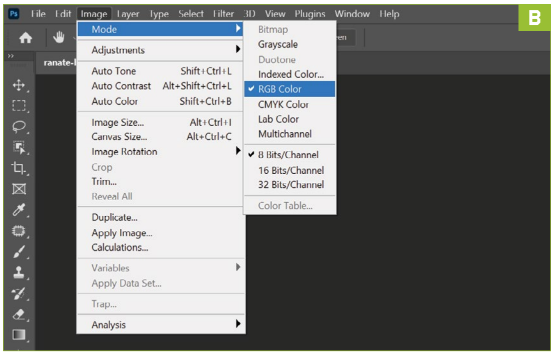

B
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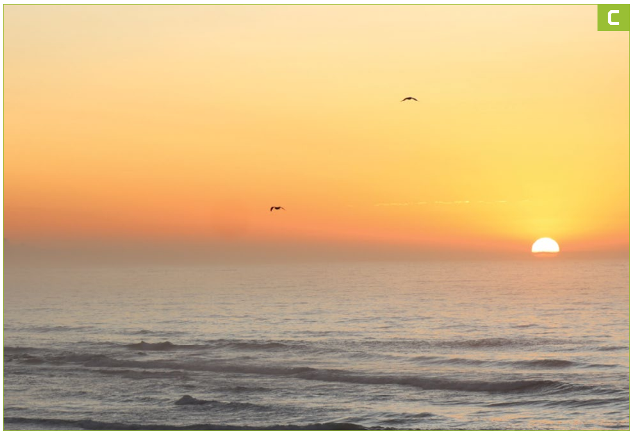
Image
Layer
Type
Select
Filter
3D
View
Plugins
Window
Help
ranate-
Mode
Adjustments
Auto Tone Shift+Ctrl+L
Auto Contrast Alt+Shift+Ctrl+L
Auto Color Shift+Ctrl+B
Image Size... Alt+Ctrl+I
Canvas Size... Alt+Ctrl+C
Image Rotation
Crop
Trim...
Reveal All
Duplicate...
Apply Image...
Calculations...
Variables
Apply Data Set...
Trap...
Analysis
Bitmap
Grayscale
Duotone
Indexed Color...
✓ RGB Color
CMYK Color
Lab Color
Multichannel
✓ 8 Bits/Channel
16 Bits/Channel
32 Bits/Channel
Color Table...



your creation as possible. If the image's destination is going to be digital, use the RGB color space [**Image B**]. Screen displays combine RGB (red, green, and blue) pixels to achieve the desired color, so it is better for digital.

›› Another essential step before we go any further is to duplicate the original layer. Always keep a copy in case you make an irreversible mistake or reach the maximum amount of "undos." To do this, go to the right of the page where the Layer panel is. There should be one layer that's named "Background," and it should be locked. Click on this layer, and you'll see a duplicate layer. A pop-up will appear, giving you the option to name the layer you'll be working on. For this example, "beach sunset" will work fine.

›› Leave the background layer locked—this will prevent any accidental changes being made to it. You will also want to hide this layer: click the eye symbol on the layer, that'll do it.

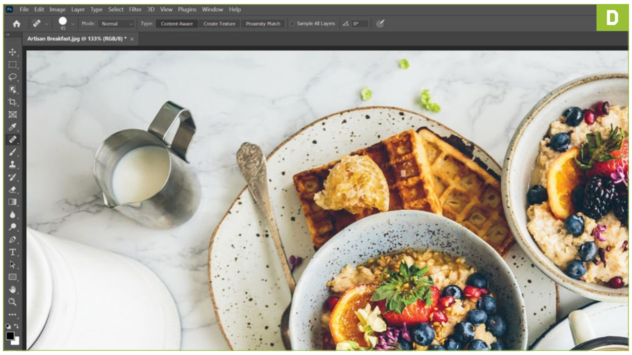
3 TIME TO DE-BIRD

So now it's time to get rid of those pesky birds. There are a few ways to achieve an untouched sky in this image. Most of the retouching tools are found under the Patch tool.

›› For this example, use the Patch tool itself. This enables you to draw around a selected part of the image, then choose another part of the image you want to cover it with. This works best when the intended blemish (the bird) is on a plain-ish background (the sky) [**Image C**].

›› To begin, you need to have the layer selected (beach sunset). Next, zoom in to the part of the image you want to edit. To do this hold Alt, point the mouse to the desired location, then use the scroll wheel to either zoom in or out. This shortcut is extremely useful to navigate around the image.

›› When the Patch tool is selected, draw around the blemish. A dashed outline should be created; drag the outline to a specific part of the image that you want to use to cover the outline—try


D
File Edit Image Layer Type Select Filter 3D View Plugins Window Help
Artisan Breakfast.jpg @ 133% (RGB/8) *

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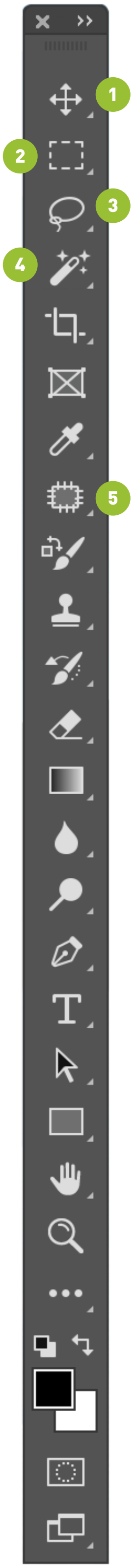
TOOL PANEL OVERVIEW



Think of this software as your virtual garage. You have all the freedom you need to create anything you can put your mind to. One of the fundamental parts of this garage is the tools. Let's go through the essentials.

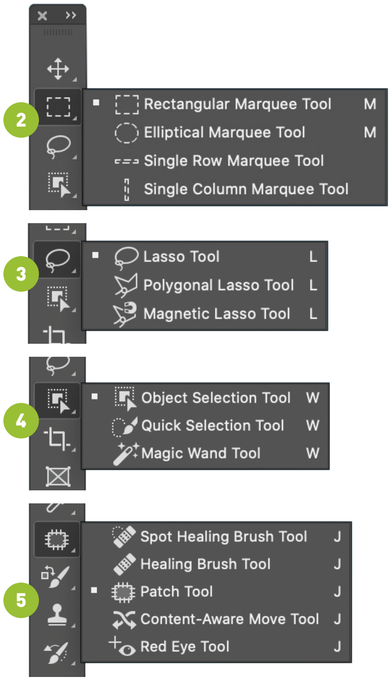
1. THE SELECT/MOVE TOOL Does exactly what it says on the can. Use this for selecting and moving images and objects around your artboard.

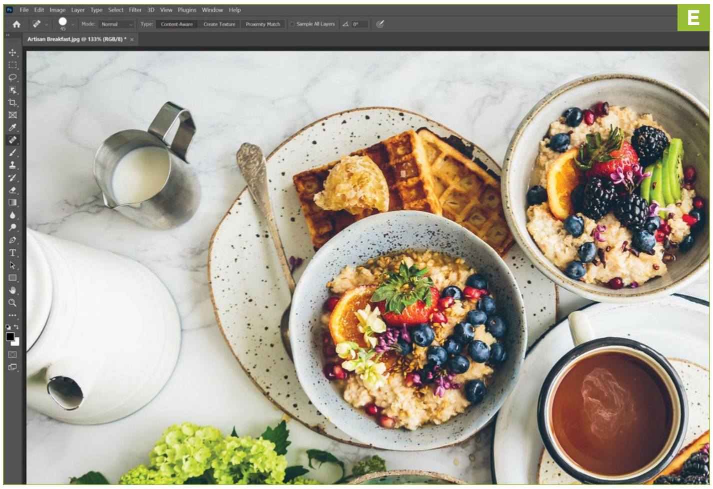
2. RECTANGLE MARQUEE TOOL Below that, you have the Rectangle Marquee tool for creating a shaped selection. A long-click on this tool will give you the option to select other shapes.

3. LASSO TOOL For more precise selection, the Lasso tool can be used. This is found below the Marquee tool. Again, with a long-click, you get more options: the Polygonal and the Magnetic Lasso tools.

4. MAGIC WAND TOOL Now we get to some of the fun tools. The Magic Wand tool can be found with a long-click on the Object Selection tool, or on the Quick Selection tool. Famed as the tool to quick-remove backgrounds, we will be going through removing backgrounds in another issue—so hold your horses for now.

5. PATCH TOOL Left-click on the Patch tool to reveal more options. Here you will find the Spot Healing tool brush, Healing tool brush, Patch tool, Content-Aware move tool, as well as the Red-Eye tool. These are the main tools we will be using for this issue's tutorial.


2
Rectangular Marquee Tool M
Elliptical Marquee Tool M
Single Row Marquee Tool
Single Column Marquee Tool
3
Lasso Tool L
Polygonal Lasso Tool L
Magnetic Lasso Tool L
4
Object Selection Tool W
Quick Selection Tool W
Magic Wand Tool W
5
Spot Healing Brush Tool J
Healing Brush Tool J
Patch Tool J
Content-Aware Move Tool J
Red Eye Tool J



Mode: Normal
Type: Content-Aware

a part of the sky that is similar in color to where you are trying to cover.

» Once you let go, you will see the magic. The bird or blemish of your choice is gone! The Patch tool is your best friend for scenarios like this. Feeling proud? See, it's a lot easier than it sounds—well for now at least anyway—but we are here to help you go further.

4 FURTHER RETOUCHING

Another retouching exercise we can do in this issue is to use the Spot Healing brush. As the name suggests, it is best used for removing spots or small distractions from an image. These can be accidental flecks of dirt on the lens or unwanted clutter in the image. We need to remove these for a cleaner image. The Spot Healing brush samples content nearby automatically, in order to place it over the area you are amending. It then blends it with the background and surroundings.

» Again, perhaps you've conveniently taken a picture of your over-engineered artisan breakfast too? Well if you take a closer look, some unwanted petals are sitting at the top of our image [**Image D**]. That simply isn't up to Instagrammable breakfast standards. Let's remove them with the Spot Healing brush.

» Zoom in to the part of the image you want to amend. Select the Spot Healing brush in the Tools panel on the left of the screen. This tool is circular, and the size of the circle can be adjusted. This can be done using the square brackets to increase or decrease accordingly. Also, at the top of the screen, there will be a circle, which indicates the brush size. Click on this to reveal the sizing, hardness, and spacing of the brush. Once the size of the brush covers the object you want to discard, simply draw over it. Again, it's so simple but does the trick [**Image E**].

» Tools like these can easily clean up an image and get rid of any unnecessary marks. As old as the saying is, practice does make perfect. Try these tools on any old images you have kicking around. Make sure to duplicate the original image layer and lock it, as mentioned earlier.

ANOTHER PHOTOSHOP TUTORIAL NEXT MONTH

5 MIRACULOUS HEALING

A very similar tool to the Spot Healing brush is the Healing tool. The Spot Healing brush is automatic, whereas you pick the source when using the Healing tool. It gives you that little extra bit of control if the Spot Healing brush isn't quite cutting it.

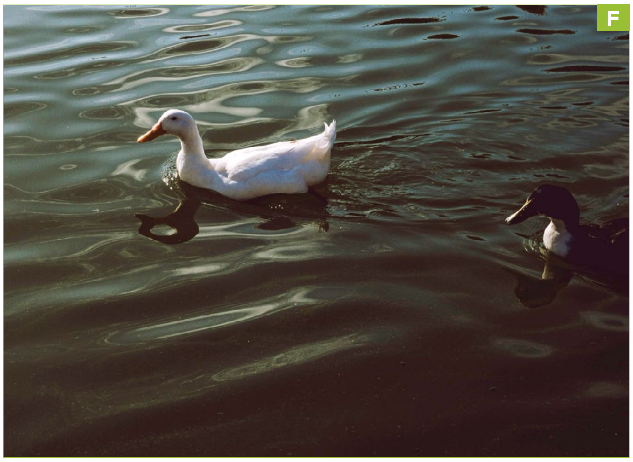
» To use this tool you can resize it just as you did with the Spot Healing brush. Here [**Image F & G**] you can see we have removed the duck on the right that was in the dark. This brings more emphasis on the white duck in the center of the shot.

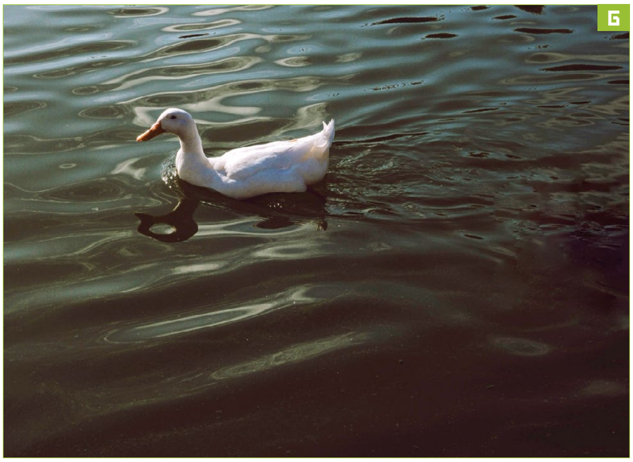
» First, you need to hold Alt to pick a source. We chose areas of dark water close to the amended area. The Healing tool enables you to then paint using the selected source. We painted over the duck in little steps, using the dark water to create natural ripples. The more natural you can get it, the better. This is where the Healing tool shows its true strengths, while the Spot Healing brush can sometimes make the amended area look blemished if it has a busy backdrop.

6 CLONE STAMPING

Do you need a larger tool to cover more area than you can with the Spot Healing or Healing brush? Then it's time to use the Clone Stamp tool. This tool works by copying and pasting without blending. In a way, it is like a bigger version of the Healing tool. You need to select a source while holding Alt, then click over the area you want to amend. Alternatively, you could use this to duplicate something.

» As you can see here [**Image H**], we've cloned the white duck to show a working example. We made sure the tool was large enough to just highlight around the duck, then, once the source was selected, we placed it in the bottom-left corner.





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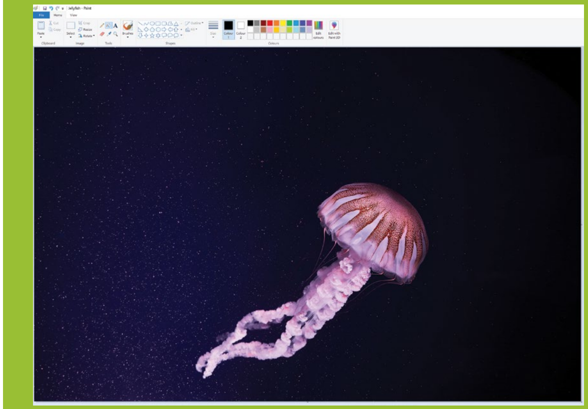
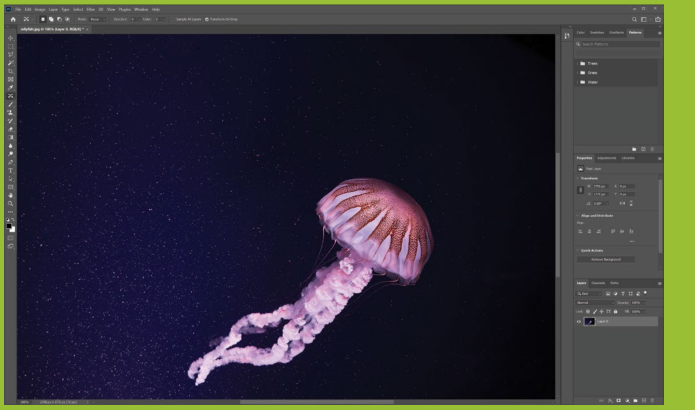
PAINT VS PHOTOSHOP





As good as Microsoft Paint is when it comes to free pre-installed software, is there a real comparison between it and Adobe's titan, Photoshop? They are both editing software, but Photoshop easily trumps Paint. In Photoshop your creativity is only capped by your imagination. In Paint, your creativity is capped by the limitations of the software itself.

Photoshop can be seen by many as overkill. To newbies, it may seem overly complex. If you're just going to be cropping and resizing images then maybe you should stick with Paint. What you want to get out of the software should be the guide to choosing between the two. If you're sitting at a basic level, then Paint is great for having some fun. Use it to test how much you can get out of the software. Once familiarized, you could turn to Paint 3D, as this gives you more options.

If your passion/work is a creative, graphic designer, photographer, or artist, then look no further, as Photoshop is the leading editing application in this field. Like most things, learning anything new can look scary, but once you are familiar you can let your creative juices flow. The biggest difference between the two software is fundamentally the price points. Luckily there is a free seven-day trial for Adobe CC to help guide your decision. After that, for Photoshop alone it's $20.99 a month, or $52.99 a month for the full suite. That's the kicker. If you know what you need Photoshop for then go and get it. If you just want to mess around and edit a little bit, Paint is the better choice.

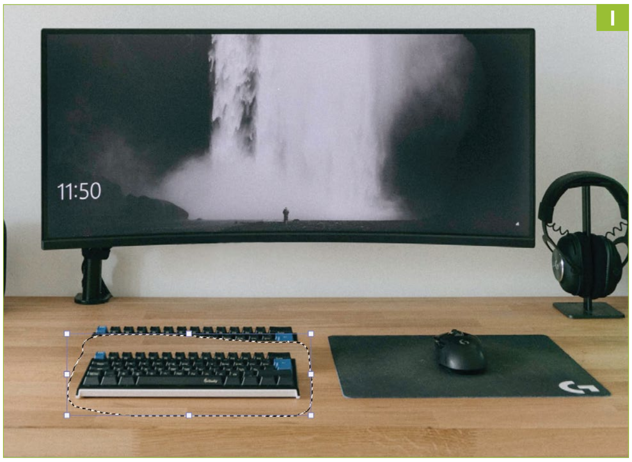
7 CONTENT AWARENESS

Finally, we will be using the Content Awareness tool. One use for this tool is to hide a large person or an object. It's also useful to move items around an image. [**Image I**] shows a desk setup: to practise using this tool we will move the keyboard to be more level with the mouse pad, by bringing it forward.

›› Select the Content Awareness tool, and draw a selection around the keyboard. Once selected, simply drag the selected item to where you feel it sits best [**Image I**]. When you feel that it's in the correct position, either hit the Enter key or click the arrow in the menu bar. If the background surrounding the moved item looks blurry/busy, retouch with the other blemishing tools you've practised using earlier. Don't forget that you can use these tools together to tackle different parts of your image. To hide an object, draw around an area with the same background as the item, and drag it over the item you want to hide. Then touch up any rough edges if you need to.

›› Hopefully we've shown you a few tips and tricks to get you all moving swiftly with Photoshop. It's a fun program, so do have fun with it, and keep practising to feed your inner creativity. ⏻

H



I

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Switch Audio Output With SoundSwitch

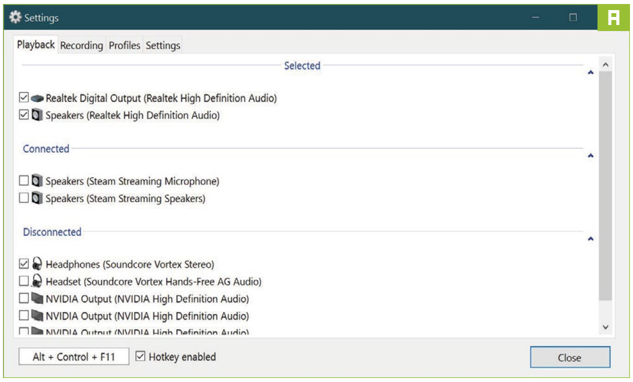
YOU'LL NEED THIS

SOUNDSWITCH
https://soundswitch.aaflalo.me/

THE BACK OF YOUR PC probably has both analog and digital audio outputs. Then there are Bluetooth headphones, USB headsets, the speakers on your monitor connected over HDMI, even external sound-processing boxes. For something that can't generate more than a harsh beeping noise unaided, your PC can actually find many ways to make a noise.

Windows doesn't always make it easy to switch between them, though, and is always liable to blast audio through your speakers when you don't want it to, or to remain stubbornly silent when you try to connect something to its digital optical output.

SoundSwitch is an open-source utility that sets your PC's audio output, and lets you choose a hotkey so you can swap the noise from speakers to headphones quickly. And it does the same for recording inputs too. It's the work of coder Antoine Aflalo. Here's how it works. –**IAN EVENDEN**



Selected

☑ Realtek Digital Output (Realtek High Definition Audio)
☑ Speakers (Realtek High Definition Audio)

Connected

☐ Speakers (Steam Streaming Microphone)
☐ Speakers (Steam Streaming Speakers)

Disconnected

☑ Headphones (Soundcore Vortex Stereo)
☐ Headset (Soundcore Vortex Hands-Free AG Audio)
☐ NVIDIA Output (NVIDIA High Definition Audio)
☐ NVIDIA Output (NVIDIA High Definition Audio)
☐ NVIDIA Output (NVIDIA High Definition Audio)

Alt + Control + F11 ☑ Hotkey enabled

1 GET STARTED

You read *Maximum PC*, so we don't need to tell you how to install this app. Once you've got it running, go to the Settings page. Here you can configure the app, tell it which inputs and outputs you want to switch between, and which combination of keys you want to use to do it. Settings opens automatically once you've finished installing, or you can right-click the icon in the System Tray and open it from the pop-up menu.

2 OUTPUTS

SoundSwitch is an unobtrusive app. Set it to start with Windows, and it sits in the System Tray. The first tab of its Settings page is Playback, where you choose the output your PC audio should use. Initially, you're presented with a list of every output installed on your machine, sorted into those that are connected and disconnected [**Image A**]. Put a check in the box next to the ones you'd like to use, then set the hotkey below (we found the default of [Alt] + [Ctrl] + [F11] a bit unwieldy, so try choosing a simpler one that doesn't clash with others you've got set up), and ensure there's a check in the "Hotkey enabled" box.

3 INPUTS

The next tab, Recording, is exactly the same as Playback but handles your PC's audio inputs, such as webcam mics, headsets, and line-in sockets. It even picked up our cell phone thanks to Windows 10's A2DP feature, which lets you stream audio from a smartphone to your PC—presumably for recording purposes, as why wouldn't you just connect it straight to your speakers? Anyway, set your input-switch hotkey and move on.

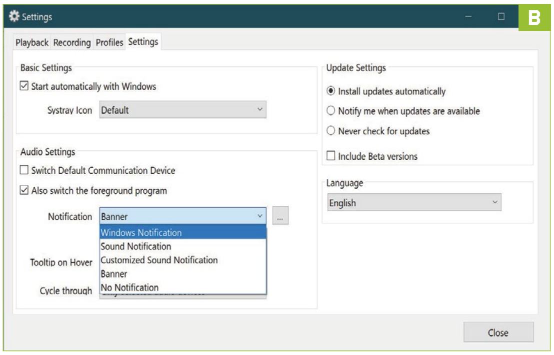
4 PROFILES

One of SoundSwitch's cleverest features, you can set it to automatically switch your input and output to specific devices when a trigger event happens, such as it detecting Steam's Big Picture mode, a specific app opening, another hotkey, or just on PC startup. Add a profile from the Profiles tab, and configure it from the pop-up. When the trigger conditions are over—for instance if you close Big Picture mode—SoundSwitch will return the audio settings to the way they were before.

5 SETTINGS

Settings within Settings contains settings for your settings—obviously. Here you'll find options to start the app automatically with Windows, install updates automatically, control tooltips, and choose what kind of notifications you receive. We like this last feature a lot, especially as it lets the app use Windows' own notification system [**Image B**], which keeps things tidy over to the right-hand side of the desktop, and can be blocked by Focus Assist. There's also a "No Notifications" option, and a useful sound notification that comes out of the newly selected output device, so you're doubly sure which one you're using. You can check what's selected at any time by hovering your mouse over the System Tray icon, and can control what information this tooltip contains.

›› Heartening to see is the large number of languages the utility is able to use—and there's a project running on the developer's site to translate it into even more. ⏻



Basic Settings
☑ Start automatically with Windows
Systray Icon: Default

Audio Settings
☐ Switch Default Communication Device
☑ Also switch the foreground program
Notification: Banner
Windows Notification
Sound Notification
Customized Sound Notification
Banner
No Notification
Tooltip on Hover
Cycle through

Update Settings
● Install updates automatically
○ Notify me when updates are available
○ Never check for updates
☐ Include Beta versions

Language: English

© SOUNDSWITCH

Microsoft MSX Architecture

YOU'LL NEED THIS

OPENMSX
For this tutorial, grab openMSX, which is available on Windows and Linux in both 32 and 64-bit versions: https://openmsx.org/
For advanced users who want BASIC or disk usage, try fMSX: https://fms.komkon.org/fMSX/

THIS MONTH'S COMPUTER is a little different. Rather than being a single system, MSX was actually a Microsoft specification for eight-bit microcomputers. Countless brands produced their own MSX machines, which dominated Eastern markets. The MSX era is a fascinating period of computing history often neglected in the West, which showcases an unusual stage of gaming evolution.

Japan in the early 1980s was flooded with home computers. Despite most machines sharing Microsoft BASIC, these computers were usually incompatible with each other. In June 1983, Microsoft announced the MSX specification: an attempt to standardize eight-bit microcomputers into a unified architecture. Rather than being an invention of Bill Gates, the MSX standard was actually the brainchild of Kazuhiko Nishi, the vice-president of Microsoft Japan and director of ASCII Corporation. Inspired by the VHS video standard, if software could work on one MSX machine, it should be able to work on any other.

The standard was designed around the Spectravideo SV 328, largely because it was built with off-the-shelf parts, and used Microsoft BASIC for an operating system.

It's unclear what MSX actually stands for. It's believed to mean either Microsoft Extended, or Machines with Software Exchangeability—though Nishi hinted that it may also refer to the MX missile! –**JOHN KNIGHT**

1

HARDWARE DEVELOPMENT

Primarily, any MSX machine needed a Zilog Z80 CPU and a Texas Instruments TMS9918 graphics chip with 16KB of VRAM, plus several standardized I/O chips. Beyond this specification manufacturers were free to do as they pleased, and all major Japanese manufacturers released machines, with some wildly varying form factors.

» RAM ranged from 16-128KB, though 64KB was the most common. Streamlined chipsets were common in budget models, and there were numerous cartridge-based add-ons. Instead of rubber chiclet keys, MSX computers usually had proper keyboards and arrow keys, which increased costs. Software usually came on either cartridge or cassette. Although disk drives were available, they weren't common until the MSX2.

2

GAMING

MSX gaming was a strange world of in-betweens. Even though games often featured impressive environments to match the consoles, the machine's single color sprites looked like something from a cheap British micro.

» MSX computers also had a console-style cartridge slot, which unlike Western micros was actually used by most games. Therefore games could often load instantly, and use a combination of the keyboard and joystick.

» Most Japanese MSX games come from between 1983 and 1987—the Japanese were quick to move onto the MSX2—and usually on cartridge. European and South American titles extended into the early 1990s, mostly on tape, or less commonly on disk.

» The underlying MSX hardware was similar to the Sega SG-1000, and many MSX titles were Sega ports. Arriving before Nintendo's Famicom (or "NES"), the MSX was Japan's platform of choice before Nintendo's eventual dominance.

» Gaming giant Konami was particularly famous on the system, and series like *Bomberman* and *Parodius* got their start on the MSX, well before arcades or consoles. Other MSX classics include *Kung-Fu Master*, *Penguin Adventure*, and *1942*.

3

LEGACY

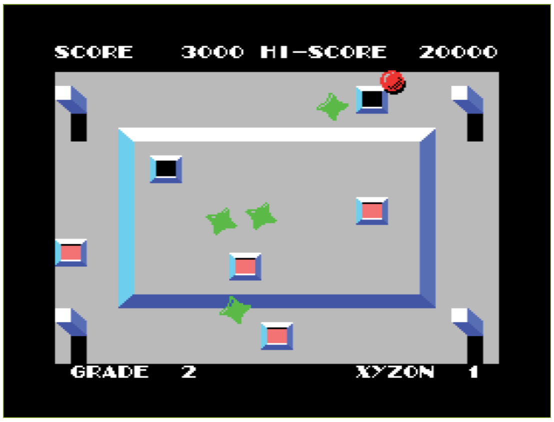
Even though the MSX wasn't popular in the US or UK, the MSX was the machine of choice in Japan, South Korea, Brazil, and Argentina. In Japan, MSX machines were dominant through the 1980s, until PCs finally became cheap enough to end their reign. By the time the MSX was discontinued, at least 5 million units had been sold.

» The MSX was followed by 1985's MSX2, as well as the MSX2+ and MSX Turbo R—machines we will explore in future issues.

4

EMULATION

Emulating the MSX isn't entirely straightforward. If you only want to play classic cartridge games, that's easy enough. But if you want to run software from tape or disk, or use BASIC, then everything becomes more complicated.



» We especially liked *Xyxolog*: an interesting physics arcade game with *Marble Madness* elements.

© 1984, TAITO

SONY
HB-10P
HiTBiT

» The MSX feels like a weird cross between a console and a microcomputer—as if a ZX Spectrum and Nintendo met in a broom cupboard.

» Multi-purpose emulators like RetroArch and MAME require BIOS ROMs in order to work, so you may as well use an MSX-specific emulator. There are two main choices: fMSX and openMSX. fMSX is bad at running cassettes, and openMSX is bad at running disks. Cassette software was more common for the original MSX, and openMSX works better across platforms, so we'll focus on that.

5 INSTALLATION AND USAGE

For Windows users, head to https://openmsx.org where you'll find the Download section in the navigation bar on the left. There are both 32 and 64-bit versions available, with the choice of "install" or "zip." Grab the "install" version. It comes with an MSI installer, which is compressed in a ZIP file, so you'll need to open or extract the ZIP file first and double-click the installer file.

» Follow the prompts, and openMSX should be available in your system menu under Programs → openMSX → openMSX.

» For Linux users, openMSX should be available either in your distro's repository, or you can use the Flatpak available at https://flathub.org.

» Once launched, openMSX is fantastic for quick and easy gaming—joysticks are automatically detected, and an excellent scanline mode is enabled by default.

» To get started, ignore the no-cartridge error message, and move your mouse pointer to the top-left of the window, where a menu button will appear. Choose "Load ROM… (slot A)" from the top of the new menu, and in the file browser pick your .rom cartridge.

» And that's it. If you don't have a joystick, most games use the arrow keys for movement, and Space to fire. Alt+Enter toggles full-screen mode.

6 DISKS AND CASSETTES

Unfortunately, openMSX's open-source ROM only supports cartridge games—you need to provide a BIOS image for cassette functionality. These are still copyright protected, though are illegally available on ROM sites; the openMSX documentation provides instructions on how to legally obtain ROMs.

» If you want to use disk images or BASIC, try fMSX, which supports both out of the box. It comes with cassette support, but it rarely works.

» If you do have a BIOS, then for Windows, copy the files into My Documents/openMSX/share/systemroms. For Linux, copy the files into ~/.openMSX/share/systemroms.

» BIOS wise, we found that "MSX System v1.0 + MSX BASIC UK (1983)" and "MSX System v1.0 + MSX BASIC Japanese (1983)" both gave us a good selection of working machines.

» To get started with cassettes, you need to launch openMSX Catapult, which should be under the same menu as openMSX. Once inside, run File → Test MSX Hardware to scan for local ROMs. Anything that openMSX recognizes will then be added to its menus of usable hardware.

» Once the scan is finished, you can select a machine from the "MSX type" menu. Anything with "C-BIOS" is an open-source replacement, so choose one of the other available entries, presuming that you provided a recognized ROM.

» To specify a tape image, click the "Cassette" button in the "Cassette Player" field, and choose "Browse cassette image." Select a .cas tape image, then click "Start" at the bottom of the window. OpenMSX should automate the loading process and run your tape image.

» If you still want to try disks with openMSX, it recognizes the Digital Design Electronica DDX v3.0 ROM, which is an add-on you can enable in the "Extensions" menu. You can browse for .dsk files in the same manner as cassettes. ⏻

SPECIFICATIONS

Microsoft MSX

CPU:	Zilog Z80A @ 3.579 MHz
RAM:	8-128 KB plus 16 KB of VRAM
ROM:	32 KB BASIC
Launch price:	N/A
Graphics:	Texas Instruments TMS9918 with 16 colors, 256x192 maximum resolution, single color sprites
Sound:	General Instrument AY-3-8910 PSG
Storage:	Cartridge, cassette, 5.25" and 3.5" inch floppy add-ons
OS:	Microsoft BASIC and MSX-DOS
Released:	June 1983
Production:	1984–1992
Worldwide sales:	5 million

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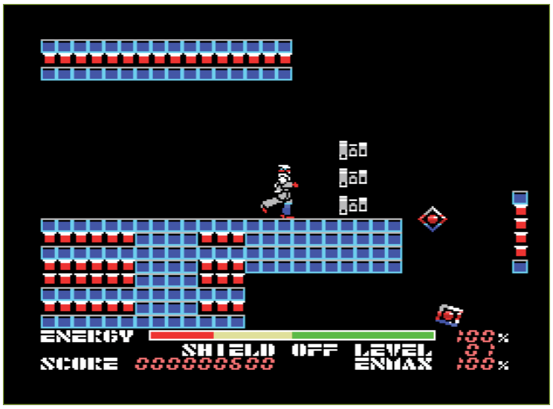


» *Thexder* is an all-time classic that seriously shows off the power of MSX, with impressive gameplay and proper scrolling.

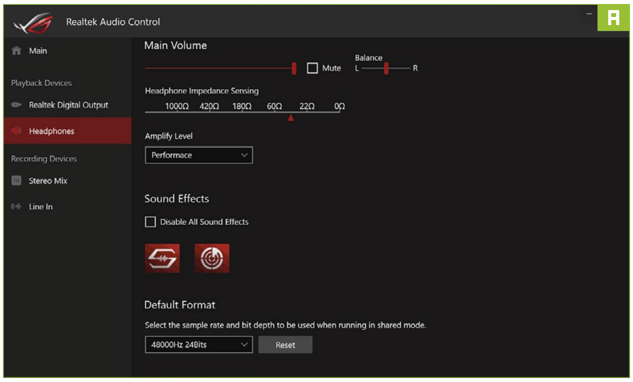
Get The Most Out Of Your Audio

YOU'LL NEED THIS

WINDOWS 7 +
Realtek Audio Console

AUDIO LISTENING IS A HUGE PART of day to day life for most people. Whether it is simply for personal use, or part of your professional role, it is important that what you are listening to is of a high quality. If you've got your headphones plugged in for long durations every day, of course you are going to want to get the most out of them. Having higher quality audio can get you more involved in what you are listening to, and immerse you in the experience—your music will reveal more layers to you, it will heighten your awareness while gaming, and hopefully, it will make any form of listening more of a pleasure.

How do you listen to audio? Is it through earphones, headphones, or speakers? There are many settings you can use to get the most out of what you already have. In this tutorial, we will show you how to get the best audio quality out of your PC through the Realtek Audio Console software, to get your audio peripherals pumping out the best sound they can. Hopefully, after this tutorial you'll be able to tweak your audio settings to exactly suit your needs. **–SAM LEWIS**


A
Realtek Audio Control
Main
Playback Devices
Realtek Digital Output
Headphones
Recording Devices
Stereo Mix
Line In
Main Volume
☐ Mute
Balance
L
R
Headphone Impedance Sensing
1000Ω
420Ω
180Ω
60Ω
22Ω
0Ω
Amplify Level
Performace
Sound Effects
☐ Disable All Sound Effects
Default Format
48000Hz 24Bits
Reset

Select the sample rate and bit depth to be used when running in shared mode.

1 WELCOME HOME

Don't make rash decisions before attempting to improve your audio—this tutorial may save you a few bucks. If you have your eyes set on a beautiful pair of headphones, just try this first. You may be expecting more out of your current headphones, and some simple settings may be holding them back from delivering the best performance they can provide.

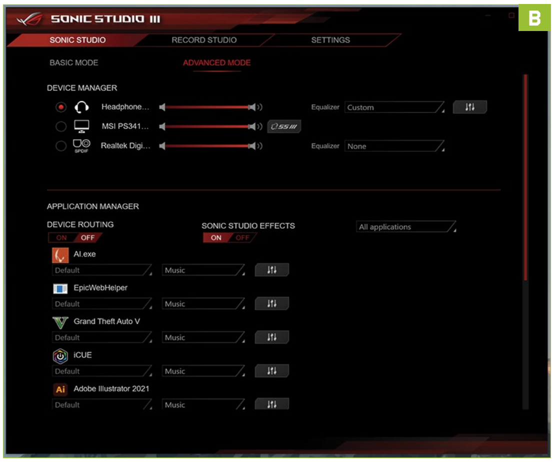
›› The software we'll be using is the Realtek Audio Console (Ours has the ROG skin but yours should look similar). In basic terms it enables you to adjust your computer's audio settings all in one program. When you open it you are greeted with the home main menu. This will display all of your playback devices and recording devices, which are also listed on the left-side panel. Through this home screen, you will be able to switch between outputs if you have more than one, and you can do the same with inputs. Other options include the ability to mute, change the volume of your selected output or input device, or go into the settings of your devices. Click the Settings button of your chosen device to open up the main settings for your headphones or speakers.

2 BALANCE AND IMPEDANCE

Once you're on your selected device menu, you can see all the settings you can alter to suit your audio needs. At the top of the screen is your device's main volume—pretty self-explanatory—followed by a Mute button, and then a left/right Audio-balancing option [**Image A**]. In some cases, this can be rather handy. An old set of headphones or speakers may be unbalanced due to usage over time, or one driver may be pumping out more than the other, so a slight tweak can sort this out right away. It's a very handy solution that can save you from ditching your old peripherals unnecessarily.

›› Below these settings, you can find out your device's impedance sensing figure. Finding this figure out can be important to help you understand what you may need to do to improve your audio setup. It can very quickly become confusing but here's a tiny bit of science: most headphones with an impedance level of 25ohm and below require less power to push high audio levels. Low-impedance headphones work best for portable uses, such as listening to music on your cellphone, laptop, or maybe even plugging a pair into your gaming controllers. That's why most headphones have a low impedance level.

›› As the impedance level starts to increase, more power is needed to deliver high audio levels. High-impedence headphones are intended for use at home or in a studio. When used with the right DAC/amplifier it can push more sound out of the headphones, offering a clearer sound, stronger bass, and overall better sound.


B
SONIC STUDIO III
SONIC STUDIO
RECORD STUDIO
SETTINGS
BASIC MODE
ADVANCED MODE
DEVICE MANAGER
Headphone...
MSI PS341...
Realtek Digi...
SPDIF
Equalizer
Custom
Equalizer
None
APPLICATION MANAGER
DEVICE ROUTING
ON OFF
SONIC STUDIO EFFECTS
ON OFF
All applications
AI.exe
Default
Music
EpicWebHelper
Default
Music
Grand Theft Auto V
Default
Music
iCUE
Default
Music
Adobe Illustrator 2021
Default
Music

3 MORE SETTINGS

Now let's take a look at the settings options below. Here you'll find the Amplify Level settings. The Performance option should be selected here—you ideally don't want to virtually increase the sound, as this can sometimes cause a lack of clarity. The other two options, Powerful and Extreme, both increase the output volume. If you do find that the maximum volume is still too low when using the Performance option, then try either of these two options, with Extreme being the loudest.

» The next option we see is for sound effects. The Sound Effects options may vary depending on your PC. The first option for our PC is Sonic Studio 3. When you click on this option it will open Sonic Studio 3 in a new window. The Studio section of the software lands you on the Basic Mode screen. Here you can play around with equalizers and create a custom equalizer. Listen to a variety of music while tweaking the equalizers to get your ideal sound [**Image B**]. Underneath that you'll find the Sonic Studio Effects, which can be toggled on or off. There are some pre-created effects for music, movies, gaming, and communication. You can alter these further by playing with the sliders.

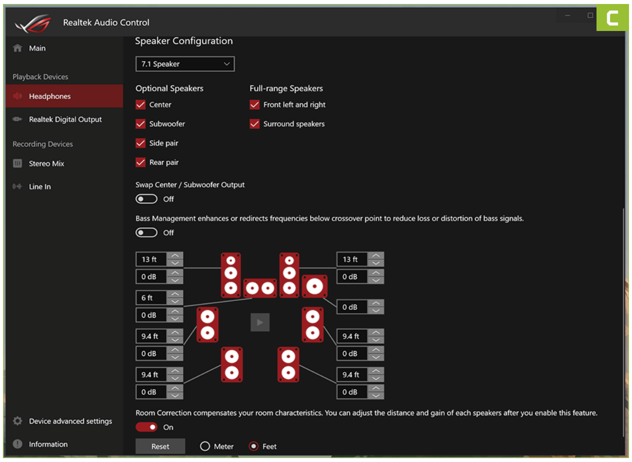
» Then there's the Advanced Mode screen. This is where you can find the Device Manager, enabling you to switch between output devices, just like with the Realtek Audio Console home screen. It also has the Application Manager. This gives you the option to set an equalizer for a specific application—for example, if a certain game sounds too bass-heavy, you can set an equalizer for this application with less bass—problem solved.

» Back in the Realtek program, the option next to Sonic Studio 3 is called Sonic Radar 3, but we won't be needing that for this tutorial, so don't sweat just yet!

4 DEFAULT FORMAT

Now we're getting into the juicy stuff, the option you need to change to know that your PC is set correctly to push out the highest audio it can from stock. The Default Format setting is the option that is usually set by default to Low. It's where you can find the sample rate and bit depth of your audio output. The higher the bit depth, the more data will be captured to recreate the sound more accurately. The lower the bit depth, the more information will be lost, resulting in reduced quality. The same goes for the sample rate—the higher the better. So whatever your highest option is, go for it. This will ensure that you have the best audio quality you can get.

» Paired with a custom equalizer, you should now be set for a clearer audio experience. Your audio should be pushing out the best it can without it being restricted. It seems odd that this isn't set to the highest by default.



Speaker Configuration
7.1 Speaker

Optional Speakers
☑ Center
☑ Subwoofer
☑ Side pair
☑ Rear pair

Full-range Speakers
☑ Front left and right
☑ Surround speakers

Swap Center / Subwoofer Output
Off

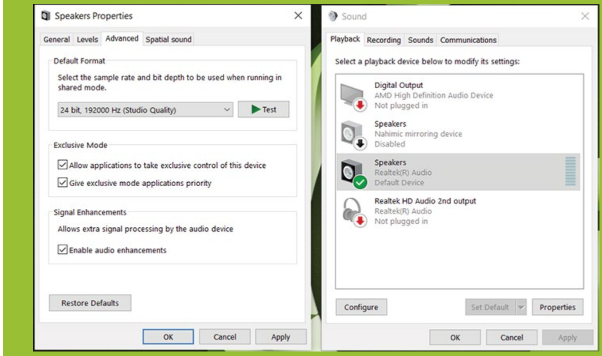
Bass Management enhances or redirects frequencies below crossover point to reduce loss or distortion of bass signals.
Off

13 ft, 0 dB, 6 ft, 0 dB, 9.4 ft, 0 dB, 9.4 ft, 0 dB
13 ft, 0 dB, 0 dB, 9.4 ft, 0 dB, 9.4 ft, 0 dB

Room Correction compensates your room characteristics. You can adjust the distance and gain of each speakers after you enable this feature.
On
○ Meter ● Feet

© REALTEK, MICROSOFT

CHECK IT TWICE



Default Format
Select the sample rate and bit depth to be used when running in shared mode.
24 bit, 192000 Hz (Studio Quality)

Exclusive Mode
☑ Allow applications to take exclusive control of this device
☑ Give exclusive mode applications priority

Signal Enhancements
Allows extra signal processing by the audio device
☑ Enable audio enhancements

Select a playback device below to modify its settings:
Digital Output
AMD High Definition Audio Device
Not plugged in
Speakers
Nahimic mirroring device
Disabled
Speakers
Realtek(R) Audio
Default Device
Realtek HD Audio 2nd output
Realtek(R) Audio
Not plugged in

To make sure the settings you have changed are working, you can check on them through the main Windows OS settings. Go to "Settings → Sound," then under the related Settings tab to the right of your screen, you should see the Sound Control Panel section.

The Sound Control Panel section will display a list of the output and input devices you have under the Playback list. Click on the device you want to check, which will open up a new Properties window. In the General tab, you can rename your device and change the devices icon—handy for a little bit of personalization. You can check the drivers for the device when clicking the Properties button. The next tab along is Levels, which quite simply is the volume and microphone level.

Next to that is the Advanced tab, and this is the one we are most interested in. It will be familiar to what we've seen in the Realtek Audio Console's Default Format mode. Once again you are going to want to make sure this is set to the highest it can be to get the most out of your PC.

Another very important step is to make sure that both boxes are ticked in the Exclusive Mode menu. This enables other applications, such as Realtek Audio Console, to take control of the audio settings for your devices. With all these settings checked you should be good to go, and be well on your way to high-quality audio listening.

5 CONFIGURATIONS

Finally, we have Speaker Configuration. Depending on your speakers, you can select the correct configuration—for example, stereo, quadraphonic, 5.1, or 7.1 surround sound. Clicking the Room Correction option enables you to virtually place your speakers in the software so that it matches your layout. This will correctly set them up, giving you a better listening experience [**Image C**].

» Realtek Audio Console is an excellent, free tool that lets you manage all of your audio needs in one place. It's easy to navigate around, and can make your audio exactly tailored to your needs. Without spending anything, you should be able to make the most out of your existing setup. Always make sure that the files you are listening to are of the highest quality too—music-streaming sites such as Tidal offer extremely high-quality music listening compared to many competitors. Audio is crucial for lots of things, so don't settle for anything but the best—fully immerse yourself in your music, gaming, work, or whatever you're getting up to. ⏻

LAB NOTES

TESTED. REVIEWED. VERDICTIZED.

The World of 3D Printing

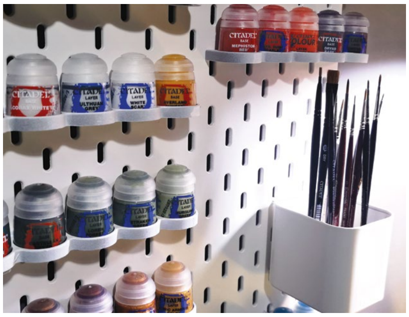
Let's face it, everybody's got a buddy called Dave

RECENTLY I've been delving into the world of painting Warhammer miniatures. It's something I like to do to pass the time, and it's quite therapeutic. I'm lucky because I've got a fairly large home office, and a massive desk. At one end is my PC, and the other end is, well, empty—an ideal space for a painting station. Now, anyone who's painted minis knows that you end up with a lot of paints. Citadel ones, the ones I use, are tiny, and a pain to store.

So I did some research online and found a company selling an accessory that you can attach to an Ikea Skadis pegboard (I have three already), and holds Citadel paints. What's the problem? Each one only holds five paints, and they're shipped from Germany, at the low low price of $9.51 per rack, plus an additional $18.80 delivery charge. $113.90 to buy 10 of those, and display 90 percent of my paints is excessive, even I can admit that. However what the company also sells is the STL file—the 3D-printing design.

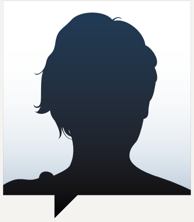
As I know Dave Alcock's into this funky fibrous world, I reached out to him for a recommendation on where to go to get some of these printed. He then proceeded to print 10 of them for me, for free, using his own printer. It took less than a day, and apparently cost him $10 in materials, which genuinely blew my mind.

So I looked into it further, and it seems that 3D printing has quietly exploded over the last few years. When it first took off, I remember thinking, "It's cool, but a bit niche," and it sort of faded out of sight of mainstream tech media. But today what you can do with a good printer is extraordinary—you can make everything from paint racks, to models, to engine parts, and the odd PC component too.



So! Would you be interested in seeing more content on 3D printing featured in the mag? If the answer is yes, feel free to drop me an email at zak.storey@futurenet.com with your thoughts, and perhaps if there's enough interest from you out there I can give this man to the right of me a bit more work on it.

INDUSTRY INSIDER



As you are probably all aware, gaming today is quite different to its humble beginnings. The market now is mainly online multiplayer and is an often highly competitive environment for players. Split-screen mode is a mere speck in the horizon of our rear-view mirror, and the prospect of having your buddies over to share a story-based game on the big screen seems like something from the distant past. Maybe this is just a sad reality of growing up, or the unalterable pathway that gaming has taken.

Online-only games have spiked, and the demise of two-player multiplayer is well underway. For people with no internet or poor connectivity, gaming as a whole is becoming more of an inconvenience to enjoy. That's not to say in any way that I don't enjoy this new era of gaming, just that I would happily welcome the social side of traditional multiplayer to return, alongside this new online age.

With the way the world has been in the last year, it was inevitable that online multiplayer gaming would thrive. It has been so important for people to stay in touch with each other, and thankfully this has been helped through gaming. But hopefully with the world gradually returning to normality, we will see an increase of traditional multiplayer in games from developers once again.

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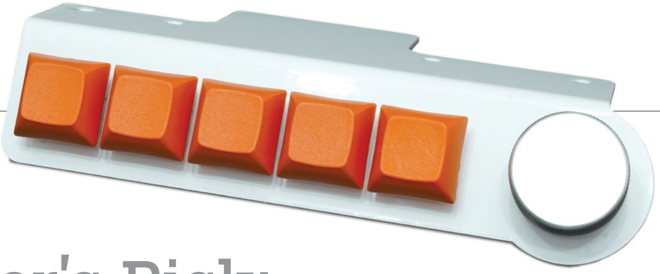


Editor's Pick: Pikatea Macropad

This pad is like a tiny five-switch keyboard with a weird-looking wheel on it

AS A LOVER of keyboards that are generally 65 percent or smaller, I sacrifice a lot of functionality that you get on full-size keyboards. Many of these functions can be added to second or even third layers, but when you just want to hit "next song" or turn up the volume, switching layers, remembering the hot key, then switching back just isn't ideal. Also, if there is an embarrassing song playing when a colleague visits, I want to be able to mute it straight away. No one needs to know about my secret love for Shawn Wasabi, and the alternative takes far too long.

Macropads are invaluable to bring back these options, and the Pikatea Macropad is my latest. It also does the trick without taking up desk space—perfect! A macropad is simply a bank of switches and/or knobs that will give you some extra functionality regardless of what keyboard you're using. The Pikatea consists of five switches and an encoder knob. The rotary encoder is just a simple knob that converts rotation into an output signal, enabling you to control things such as volume or mouse-scrolling, or scrubbing in video-editing suites. With this combination you're able to set 13 functions. The five switches can either be short-pressed or long-pressed, and the encoder can be spun in both directions, as well as pressed down.

My current configuration is nice and simple: volume on the encoder, press to mute. The five switches are set to control media as well as muting/unmuting the microphone. When I long-press the five switches, they're just F1-F3, and then F9 and F12 as well. These are shortcuts I use a lot for work, and with 40-percent keyboards I have to change layer, then use Fn + another key for my F row—not ideal.

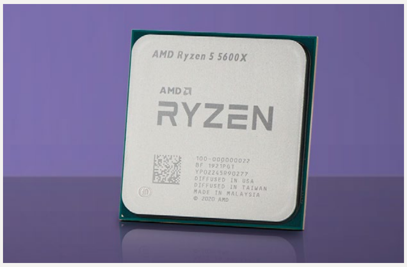
Programming the Pikatea is easy. You don't need to install any software, you just edit a TXT file on the micro-SD card that is included. If this doesn't give you the control you need, you can also flash it with QMK or QMK VIA, which then enables you to code the Pikatea with far more options. You can also use the Pikatea in conjunction with the AutoHotkey software for even more power. For example, you could set a single-key macro that can stop all music, switch output device to your headphones, unmute your microphone, and switch the screen to your chosen communication program. This would be great if you're important at work, have lots of friends that call you, or need to be contacted for other reasons. As you can see, I didn't need to do this, unfortunately. You can also set the Pikatea to work with OBS, so you can change scenes or start/end stream easily, similar to an Elgato Stream Deck.

What sets the Pikatea apart from some other macropads is its the ability to mount it either under a desk or monitor. This is what swung me, as I have a lot of other devices on my desk and wanted this to be easily reachable. I put it just to the left under the desk. There are two mounting options: double-sided tape, or simple wood screws. Pikatea includes these too.

There are different versions, and you can choose whether you want it prebuilt or to do it yourself. You also have options on color, material type, and mechanical switch type. Each option has a different cost, and a macro pad will always be quite expensive due to the controller and PCB work that goes into it. All in all though, if you like quirky devices that have functionality, the Pikatea is one to play with. **–DA**

$68.69-$90.69 www.pikatea.com

Reviewed...



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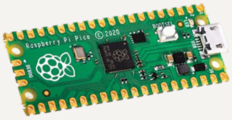

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AMD Ryzen 5 5600X

The runt of the litter delivers where it counts

THE RYZEN 5 5600X is the most affordable of the Zen 3 family released so far. If there's one serious criticism of it, it's that this time around the chips are a bit on the pricey side. This is less of a problem for high-end chips, where time is money and high performance can claw back time, but as you head down the stack and focus more on gaming, the pay-off needs to be more immediate.

Enter then the 5600X. While you couldn't really call $299 a budget CPU, it is a more manageable, mainstream price point that's historically seen plenty of competition. Currently you're looking at the likes of the Core i7-10700K, which can be had for around $375, while a more direct comparison is with the Core i5-10600K, which will set you back $275.

As with the other Zen 3 chips, this update to the 3600X has seen a $50 price increase, although unlike the other chips, you do still get a cooler with this one. This gives it the value edge over Intel's offerings (which don't ship with coolers), all other things being equal.

This bad boy is a six-core, 12-thread processor with a base clock of 3.7GHz and max boost of 4.6GHz. It's built up of a single core complex that has 32MB of L3 cache to call its own, and the same I/O die that can be found in Zen 2. As with the other chips in the Zen 3 family, you'll often see the boost clocks rise above the official 4.6GHz limit. Even using the Wraith Stealth cooler, you'll get the cores running at 4,650MHz, and with a water cooler 4.7GHz isn't unheard of—at least in single and dual-threaded applications.

AMD officially supports up to 3,200MHz DDR4 RAM with its latest gen chips, although you'll be able to run much faster memory without issue. The Infinity Fabric runs at 1,800MHz by default, so pairing it with 3,600MHz DDR4 makes sense. There is the potential for a faster Infinity Clock (FCLK) through BIOS updates in the future as well, although AMD isn't guaranteeing this at launch.

Although it only has six cores, this thing is still a powerhouse compared to Intel's similarly priced 10600K, with stronger figures in the X264 video-encoding and Cinebench R20 3D-rendering benchmarks. In fact, the 5600X is closer to Intel's 10700K, which is impressive given that the 10700K has eight cores.

It's the gaming performance where AMD really impresses, however, producing figures that can take on the top of Intel's processor stack, the 10900K—a chip that costs double what AMD is asking for the 5600X. It's not so good in every game, to be fair, but overall there's nothing between this $299 CPU and Intel's $599 10-core, 20-thread monster.

The AMD Ryzen 5 5600X is a surprisingly awesome gaming chip. It's not the monster in serious workloads that the more expensive chips are, but then this does only have six cores and 12 threads to play with. It'll still see you fine if you want to dabble in 3D rendering and video encoding, but if that's your focus, then you're going to have to spend more.

The stock cooler is fine for basic performance, although the way that Precision Boost 2.0 works means that you won't hit the full potential of the 5600X until you throw a beefier cooler at it. This really only matters for serious number-crunching, because in testing it didn't hold back game performance at all.

Overall, this is another win for the Zen 3 architecture and for AMD. Sure, it's $50 more than we would have liked, but the inclusion of the cooler helps to offset this. The more important win is for us gamers: we don't have to pay over the odds for great gaming performance anymore. **–ALAN DEXTER**

BENCHMARKS

	AMD Ryzen 5 5600X	AMD Ryzen 9 5900X	Intel Core i5-10600K
Cinebench R20 Single (Index)	600	**638**	488
Cinebench R20 Multi (Index)	4,292	**8,348**	3,528
X264 v5.0 Video Encoding (avg fps)	39.42	**75.1**	31.3
SiSoft Sandra Memory Bandwidth (GB/s)	37.15	**37.6**	34.7
3DMark Time Spy (Index)	13,019	**14,100**	12,907
Civilization VI AI Test (seconds)	7.02	**6.57**	6.84
Total War: Three Kingdoms @ 1080p	153	**154**	139
Far Cry New Dawn @ 4K	**83**	**83**	**83**

Best scores in bold. Our test bed consists of an Gigabyte X570 Aorus Master, 16GB Thermaltake DDR4 @ 3600, an Nvidia GeForce RTX 2080 Ti, 2TB Sabrent Rocket PCIe 4.0 SSD, and a Corsair H115i RGB Pro XT.All games were tested on the high profile.

VERDICT
9
KICK ASS!

AMD Ryzen 5 5600X

+ BUDGET BUSTER Strong gaming performance; solid value; cooler included.

– MONEY MANIPULATOR Needs an AIO for best performance; low stock.

$300 www.amd.com

SPECIFICATIONS

Cores / Threads	6 / 12
Base / Turbo Clock	3.7 GHz / 4.6 GHz
Architecture	Zen 3
Lithography	TSMC 7nm+
Memory Support	DDR4 3200 MHz
PCIe Support	16+4+4 PCIe 4.0
Integrated Graphics	N/A
TDP	65W

AMD Ryzen 5 5600X
AMD
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MADE IN MALAYSIA
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This is a chip for anyone
who enjoys gaming.

MSI Bravo 15

Not quite bravo enough

MSI'S VISION is that of a world leader in gaming solutions, and the company is unwaveringly committed to cutting-edge innovation and aesthetic design. The Bravo 15 sits in the middle of MSI's budget gaming laptops. It follows on from the previous Alpha 15, with an AMD CPU and GPU. MSI boasts that it's combined the most advanced 7nm AMD Ryzen processor and Radeon RX graphics. This, along with FreeSync Premium, aims to provide stunning performance and a smooth gaming display for the price. On paper, it's pretty impressive.

This can also be a negative, however. The problems start when you consider the price range and where it sits in MSI's lineup. Compromises are to be expected when you're just over the $1,000 mark. It's not the ugliest laptop by any means—the finish is a shiny brushed aluminum, which gives it a futuristic look that certainly fits in with the gaming aesthetic. Unfortunately, cheap materials house the laptop, resulting in a less-than-premium feel. Lid flex is very apparent, and a slight knock causes screen wobble. Let's just say that it's not the sturdiest machine we've come across.

Typing on the keyboard feels slightly bleak. Key travel is minimal, and the keys are soft. They're finished with a red edging and have red LED backlighting, continuing that "gaming" aesthetic. It would be nice to have a little bit more RGB customization. Moving on to the trackpad, it's fast and responsive, although it does feel light and a bit cheap when clicking. For on-the-go usage it should be more than adequate, but you'll want to hook a keyboard and mouse up to this to get that full gaming experience when sat at home.

Battery life is not too bad. MSI claims seven-plus hours of entertainment, but that's when using Super Battery mode. It's certainly not the best when using performance settings. You'll get two hours of gaming out of this, so in reality you'll be plugging it in for performance.

BUDGET GAMING

What's a gaming laptop without the power to show? Just a laptop really. The Bravo 15 is decent on the whole when it comes to gaming—the AMD CPU and GPU work well together to get the most out of the performance. With technology such as AMD's FidelityFX and FreeSync, it gets the job done. It's probably wise to avoid ultra settings on most games to achieve that ideal 60fps mark. With a few tweaks, you should be able to get a smooth gaming experience with minimal issue.

It has thin bezels on the sides, which is always welcomed, but the bezels are certainly less than "thin" on the top and bottom of the display. When immersed in gaming it's not so distracting, but otherwise it doesn't look that great. The screen itself is divisive. It's a 15.6-inch 1080p IPS panel. That sounds decent, but the color accuracy is not quite good enough. For day-to-day use, the colors seem washed out and slightly dull compared to other IPS screens. Brightness isn't the best either, which can be frustrating at times. Glare from lighting seems to be a key issue for this display as well. The saving grace is the refresh rate, which is a light and snappy 144Hz—perfect for your gaming needs.

Another bonus for the MSI Bravo 15 is its connectivity. On the right side, you get a power jack and an HDMI port. On the left you get four USB ports—two Type-A and two Type-C, both USB 3.2 Gen 1. You also get a headphone/microphone jack and a Gigabit Ethernet port as well.

Overall, then, the Bravo 15 seems to be floating around in the middle of the budget market. It's not terrible, but nor is it outstanding—it's just an overall solid product. If you can turn a blind eye to the cheaper build quality and the dull screen, and focus on what this is for—gaming—then it's absolutely a decent pick. However, there's just too many small problems for us to truly recommend it. **–SAM LEWIS**

VERDICT
7

MSI Bravo 15

➕ **BANG FOR BUCK** Ergonomic design; good refresh rate; Hi-Res audio; high-powered AMD design.

➖ **NOT THE FULL PACKAGE** Cheap feel; shallow keys; a washed colored display.

$1,049, www.msi.com

GAMING LAPTOPS BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	1,826 (77%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	1,239 (-63%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	982 (-61%)
3DMark: Fire Strike (Index)	13,610	11,547 (-15%)
Rise of the Tomb Raider (fps)	92	70 (-24%)
Total War: Warhammer II (fps)	62	42 (-32%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	28 (-42%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	AMD Ryzen 7 4800H @ 2.9 GHz
Graphics	AMD Radeon RX 5500M with 4GB GDDR6
RAM	16GB DDR4-3200
Screen	15.6-inch IPS 1080p @ 144Hz
Storage	512GB M.2 NVMe SSD
Ports	1xHDMI, 2x USB 3.2 Gen1 Type-A, 2x USB 3.2 Gen1 Type-C, 1x HP-out/mic-in, 1xRJ45 Ethernet
Connectivity	Intel Wi-Fi 6 AX200, Bluetooth 5.1
Weight	4.3 lbs
Size	0.9 x 10 x 14.1 inches

Thin side bezels allow for an immersive experience.

GRAB YOUR PI AND START CREATING!

The Raspberry Pi is one of the most exciting things to happen to computer technology in recent years. As an educational tool, this tiny PC has reignited interest in bare-metal computing in homes all over America

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Sabrent Rocket 4 Plus 2TB

Is this really the world's fastest NVMe SSD?

DO YOU DEMAND the absolute fastest M.2 SSD, hands down? Samsung's 980 PRO is an object lesson in solid-state speed. In our hands, the 1TB version of Samsung's NVMe finest knocked out over 7GB/s of read and 5GB/s of write performance.

That's as good as we've seen from an M.2 NVMe drive. Actually, it's redolent of RAM speeds from not entirely distant memory. But it's not enough to beat Sabrent's new beast—not on paper, at least. So here we have the new Sabrent Rocket 4 Plus. Like the Samsung 980 PRO, it's an M.2 drive with a quad-lane PCI Express 4.0 interface running TLC NAND flash memory. However, in the Rocket 4 Plus, Sabrent has created what it claims is the fastest NVMe SSD on the planet. The cold, hard numbers? 7.1GB/s of raw read speed, and 6.6GB/s of writes. For the record, Samsung claims that the 980 PRO is good for up to 7GB/s on the nose for reads, and 5GB/s writes.

As for how Sabrent achieves this, under the hood is Phison's latest SSD controller, the PS5018-E18, known as the E18. It's an eight-channel NVMe 1.4 beast manufactured on TSMC 12nm, and packing five cores—three of them generic ARM Cortex R5 items, with the other two being a proprietary Phison design. Phison reckons the E18 is capable of 7.4GB/s read and 7GB/s write speeds, plus 1 million IOPS. In short, it's a state-of-the-art SSD controller by client PC standards.

Those are maximum theoretical numbers, of course. Indeed, Sabrent is only claiming 650K read and 700K write IOPS for the Rocket 4 Plus. Anyway, hooked up to that controller is 2TB of Micron-made 3D TLC NAND memory and 2GB of DDR4 cache. All told, Sabrent rates the endurance of this 2TB variant at 1,400TB of writes, a figure backed up by a five-year warranty.

Add in a quality copper heat-spreader and a slick metal presentation case, and the Rocket 4 Plus really does make a strong initial impression. But does it actually deliver the goods hooked up to a PC? The raw sequentials certainly don't disappoint. In fact, the Rocket 4 Plus delivers slightly faster writes than the official specs.

It also impresses when it comes to 4K random writes, clocking up 239MB/s at queue depth one—a fair bit quicker than the 194MB/s the Samsung 980 PRO achieved in our testing. Slightly less impressive are the 4K random read numbers, with the Rocket 4 Plus registering 68MB/s. That's by no means bad, but in the context of its near-total domination in other synthetic tests, it's a notable area of relative weakness.

Back in the real world, the Rocket 4 Plus's sustained performance is particularly impressive. When filling the drive with large data files via internal copying, the Rocket 4 Plus sustains its initial 2GB/s of performance for over 600GB, before dropping to 1GB/s for a further 100GB, then intermittently bouncing between 1GB/s and 500MB/s. By contrast, the Samsung 980 PRO only sustains peak internal copy performance for 50GB of data before dropping to 1GB/s.

In other words, this drive will stand up to huge quantities of traffic before suffering from slow-downs of any kind, be that due to exhausting SLC write cache or the controller chipset overheating. All of which means that the new Sabrent Rocket 4 Plus doesn't quite win every single benchmark metric. But it comes awfully close, and does enough overall to convince that it's worthy of its lofty claim. This very likely is the fastest NVMe SSD in the world. That it slightly undercuts the Samsung 980 PRO on price just makes the Rocket 4's proposition that little bit sweeter. Nice job, Sabrent. –**JEREMY LAIRD**

BENCHMARKS

	Sabrent Rocket 4 Plus 2TB	Samsung 980 PRO 1TB
Crystal Disk 6 Sequential Read/Write (MB/s)	7075 / **6,836**	**7,098** / 5,172
Anvil 4K QD 1 Read/Write (MB/s)	68 / **239**	**83** / 194
Anvil 4K QD 2 Read/Write (MB/s)	134 / **435**	**168** / 384
Anvil 4K QD 4 Read/Write (MB/s)	265 / **708**	**328** / 648

Our test bench consists of an AMD Ryzen 9 3800X, an Asus Crosshair VIII Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD. Best scores are in bold.

VERDICT

9

KICK ASS!

Sabrent Rocket 4 Plus 2TB

+ LIGHT SPEED The fastest M.2 SSD we've tested by most metrics; great endurance.

− LIGHT ON SPEED Not quite a world-beater when it comes to 4K random reads; very little else.

$399 www.sabrent.com

SPECIFICATIONS

Format	M.2
Interface	PCIe Gen 4 x4
Control protocol	NVMe
Controller	Phison E18
Capacity	2TB
Memory type	3D TLC NAND
Cache memory	2GB DDR4
Sequential Read Speed	7,100MB/s
Sequential Write Speed	6,600MB/s
Read IOPS	650K
Write IOPS	700K
Warranty	5 years

Samsung CRG9

Too much of a good thing?

NO LESS than 49 inches of premium ultrawide panel tech; high refresh; HDR support; 5,120 x 1,440 pixels—if that sounds like a recipe for a pretty niche, premium product, it hasn't prevented Samsung from cooking up at least three different monitor models that tick all those boxes.

It may actually be more than three—it's hard to keep track of Samsung's sprawling product range. The most famous of what we'll now call the "known trio" of 49-inch Samsung ultrawides is the epic G9. That one wowed many a YouTuber and reviewer with its crazy-tight 1,000R curvature, 240Hz refresh, and its DisplayHDR 1000 certification.

But we've got the CRG9, sometimes also known as the C49RG90, which scales that back to 120Hz and 1,800R, while retaining the same resolution and DisplayHDR 1000 certification. Okay, this may not be the mighty G9, but it's still a beast of a monitor.

Before we get to the sheer visual impact of such a huge, ultrawide panel, it's worth covering some of the other specifications. The DisplayHDR 1000 rating translates into 600cd/m2 of peak brightness across the panel, with 1,000cd/m2 reserved for localized hotspots.

Speaking of which, as the DisplayHDR 1000 rating implies, the CRG9 does indeed have local backlight dimming. However, that's composed of just 10 vertical zones. In other words, that's nothing like as precise as the full-array local-dimming solution of screens with hundreds or even thousands of zones.

That said, the CRG9 does use VA panel tech, which helps it achieve an impressive 3,000:1 static contrast ratio. As for color accuracy, Samsung rates it at 95 percent coverage of the DCI-P3 gamut, which is a solid effort. Less impressive is the 4ms rated response time. That's a gray-to-gray rather than rise-fall rating. So, on-paper the CRG9 is some way off the best IPS and TN panels for speed of response.

But pixel response is far from your first concern when you fire up the CRG9.

No, you'll be too busy giggling at the ridiculous scale and shape of the thing. We've seen 49-inch 32:9 aspect ratio monitors before, and yet they remain a mind-blowing sight. By the numbers, what you've got is equivalent to a pair of circa 25-inch QHD monitors fused into a single panel. But the feel and impact is much more spectacular than that.

That said, for desktop productivity work, we have our doubts. Even with 5,120 x 1,440 pixels, the 49-inch diagonal translates into a rather mediocre 109 pixels per inch—a high-DPI monitor this is not. It's a little short on vertical resolution, too, with just 1,440 pixels. That's far below the 2,160 pixels of a standard 4K monitor. Still, the default factory calibration is pretty decent in the panel's native wide-gamut, with sRGB mode optionally available.

Of course, what this panel is really all about is gaming, and there's absolutely no question it makes for a spectacular experience. As with most modern VA panels, visuals are super-contrasty, rich, and vibrant. This may not be a true HDR panel due to its limited local dimming support, but it's still seriously punchy.

It's also not the most responsive panel on the planet. Samsung does offer multiple levels of overdrive via the CRG9's OSD menu. Ramped fully up, pixel response is decent, but at the cost of some fairly obvious overshoot and inverse ghosting. At lower levels, some characteristic VA black tone smearing is apparent. It's not a really serious issue, but it is relevant given the gaming remit.

In the end, what you'll make of it all depends on how sensitive you are to those kinds of issues. Certainly, this monitor won't be a great pick for eSports addicts. It's not ideal from a productivity perspective, either, especially if you seek a high-DPI experience. But for a certain kind of immersive gaming, it makes for one heck of a ride. **–JEREMY LAIRD**

VERDICT

8

Samsung CRG9

+ AGE OF ULTRONWIDE Huge, glorious, punchy VA panel; immersive gaming experience.

− THE INCREDIBLE HULK Limited local dimming; far from a high-DPI panel

$1,199 www.samsung.com

SPECIFICATIONS

Panel size	49-inch, 1800R curve
Panel type	VA
Native resolution	5,120 x 1,440
Refresh rate	120Hz
Contrast	3000:1
Response	4ms
Brightness	600 nits
Inputs	HDMI 2.0 x1, DisplayPort 1.4 x2
Other	FreeSync 2, 4x USB 3.0 hub, VESA 100mm x 100mm

The CRG9 is just one of several 49-inch ultrawide Samsung monitors.

When will we get ITX cases Corsair? When?

Corsair 5000D Airflow

Gratuitous flexibility made manifest

A FEW ISSUES BACK we took a look at Corsair's latest chassis innovations in the form of its 4000D Airflow case. Announced in Q3 2020, the 4000 series represented a paradigm shift for the company, away from its old naming schemes and design decisions toward this new, reinvigorated format. For those that don't know, the first number in the chassis designation indicates the size of the chassis, and then the D, D Airflow, or X moniker identifies what design aims it's trying to achieve, and of course at what price. You have the standard D, designed with silent, slick, optimized budget-running in mind; the D Airflow, which is similar to the former but better optimized for airflow; and the X, which is an all-singing and dancing RGB tempered-glass affair, for those with a premium budget.

So, 4000 is the mid-tower series, 5000 is verging closer to full-tower, but more like a mid-tower+ really. We're guessing there'll be a 2000 series and a 3000 series for ITX and M-ATX respectively, and we'd be highly surprised if there wasn't a 6000 series full-tower lineup by the end of the year too.

The 5000D Airflow, then, is a slightly enlarged variant on the 4000D Airflow that we've already reviewed. A lot of the same design features and aesthetics are present throughout. From the general patterns, branding, and tiny yellow accents littered around the place, the chassis is without a doubt very slick, and a fantastic improvement on the last generation of Corsair cases. What's particularly nice about this is that Corsair has managed to redevelop all of these cases, without necessarily falling into the trap of inflating the price or introducing a "Corsair brand tax" that you'd find with Asus or others. In fact, on the whole we'd argue that they're actually really well priced and positioned on the market. Competition is fierce right now in this sector, and there are a lot of good cases out there from the likes of Phanteks and NZXT, so to see these cases come in and effectively undercut the competition, while still providing a lot if not all of the same features, is a sight for sore eyes.

Internally the design between the D, D Airflow, and the X doesn't really change. You get a very roomy interior, support for E-ATX, rubber cable grommets, cable tidy bar, hinged doors in the rear to help hide messy cable management, a full-size PSU cover with suitable ventilation, and a raft of support for cooling solutions too. And it's that latter point that really makes this case series shine. It's not impossible to install 13 separate 120mm fans in this chassis. You can install three 120mms in the front, three in the side, six in the roof (with an AIO, thanks to push pull), and one in the rear You've also got liquid cooling support of a similar caliber, and it all looks very classy. The side-mounting fans in particular are a very nice inclusion, as it's a feature typically reserved for cube-chassis designs, as opposed to full-towers. In fact, Corsair's even gone to the length of having a specially cut, tempered-glass panel on the X series to allow air to pass through if you decide to install fans there.

If you've read our 4K gaming feature this month, you'll know that this case is exceptional, and after building in it, there's very little here for us to criticize. Airflow is good, compatibility is good, the accessory kit is solid. The only thing that really annoys us is the alignment on the front and side fans (which is probably down to us installing an AIO where we're not really meant to), and the thumb screws to remove the 3.5-inch hard drive cage being particularly tight.

The 5000D Airflow is a fantastic case, at an excellent price point, and if you're looking for a new place for your next system to call home, you will not be disappointed if you splash the cash on this impressive chassis. **–ZAK STOREY**

VERDICT
9
KICK ASS!

Corsair 5000D Airflow

+ DYNAMIC Huge cooling potential; looks great; strong price point; integrated fan controller; multiple variants; great design features.

− DUD Hard drive cage thumb screws are too tight.

$150 www.corsair.com

SPECIFICATIONS

Motherboard Support	E-ATX, ATX, M-ATX, ITX
2.5 / 3.5-inch Support	4x 2.5-inch, 2x 3.5-inch
Max Radiator Support	360mm Front, 360mm Roof, 360mm Side, 120mm Rear
Fan Support	3x120mm / 2x140mm Front, 3x 120mm Side, 3x 120mm / 2x 140mm Roof, 1x 120mm Rear
Dimensions	20.5 x 9.6 x 20.5 inches
Graphics Card Clearance	16.5 inches
CPU Tower Clearance	6.7 inches

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Sony WH-1000XM4

If it ain't broke don't fix it, just tweak it?

SINCE ITS 1979 launch of the Walkman companion headphones, Sony has been at the forefront of commercial audio tech, and the WH-1000XM4 is a fine example of that, as they lean ever closer towards "affordable" audio perfection.

At first glance, you might not get the sense that these headphones contain some serious power under the hood, as this power is hidden under an elegant and sleek body. Its smooth matte monocolored finish pushes the idea that Sony wanted sophistication with substance. It hasn't visibly changed much from its predecessor, but that isn't a bad thing—Sony has swayed us with that "less is more" mindset. Brass/gold accents continue that minimal design language but give the headphones a touch of class. The look is a timeless one.

As far as size goes, the cans don't protrude from the head obnoxiously, allowing them to sit snugly on your cranium. Slightly more padding on the headband and cups is welcome. Using them all day feels effortless, and the memory foam soft-touch leather creates a perfect cushion for your ears. The soft-touch plastic construction feels less premium, but the comfort is sublime.

Active noise cancellation plays a huge part in the immersive experience. Without playing music, they cut pretty much all background noise out. In the companion app, the ambient sound control enables you to choose how much noise-canceling you want your headphones to have—the more ambient noise, the less noise canceling.

With this feature turned on you can expect 30 hours of use, and 38 hours with it turned off. That's plenty, considering you should probably not be awake for that long. 10 minutes of charge with the provided USB-C cable gives you up to five hours of audio listening, which is pretty impressive.

These cans are packed with features, boasting Bluetooth wireless connectivity, 360 reality audio, Google assistant, Alexa built in, Hi-Res Audio, hands-free calling with HD Voice, Sense Engine, LDAC, digital noise canceling, and DSEE Extreme. These cans have multiple device connectivity too, so you can pair them to your phone and PC, and seamlessly switch between the two.

A touch-sensitive right earcup offers quick playback accessibility. Covering the cup with your hand turns off the noise cancelation and lowers the volume—a great feature for communication. The left earcup is fitted with a proximity sensor, pausing your track whenever you take the headphones off, and resuming it when you put the headphones back on. It all becomes very intuitive with a little bit of patience and practice.

We probably should mention that they sound extremely good too, right? If anyone is familiar with the WH-1000XM3, the WH-1000XM4 carries the same colorful characteristics. The circumaural 40mm drivers produce a progressive and powerful soundstage, treating your ears to copious amounts of bass and crystal-clear clarity at the top end. Sony's 360 Reality Audio is excellent when paired with a supporting streaming site such as Tidal. The sound produced engulfs you, placing you in the middle of the mix.

These cans seem to be able to handle any genre you throw at them. In alt-rock, the guitars are crisp and clean, drums are punchy, and the bassline is super-smooth. EDM is filled with heavy bass and velvety keys. The bass, mids, and trebles work hand in hand, creating a very balanced performance, and nothing seems to override any other element of a song.

The retail price tag is $350 but often floats around the $300 mark. For a pair of headphones that can cover anything you throw at them, are incredibly comfortable, packed with features, and look the part, you can't go wrong. With only a few tiny gripes, Sony has hit the nail on the head, pairing sophistication with substance. It's just a shame the name isn't as sophisticated. **–SAM LEWIS**

VERDICT

9

Sony WH-1000XM4

+ PACKS A PUNCH Great soundstage; cloud-like comfort; full of features; leading active noise cancelling.

− GAPS IN THE GUARD Not water-resistant; call qualities are lacking; lots of plastic.

$350, www.sony.com

SPECIFICATIONS

Driver Type	40mm dynamic
Frequency Response	4-40,000Hz
Design Style	Closed, dome
Connection Standard	2.4GHz, Bluetooth
Battery Life	30 hours (38 hours w/o ANC)
Weight	0.56lb

Razer Naga Pro Wireless Mouse

One mouse (with many buttons) to rule them all?

SINCE ITS ORIGINAL release in 2009, the Naga has become one of the figureheads of the Razer line-up. Mainly targeting players of MMO and MOBA games, the up to 12 side buttons make it an instantly recognizable mouse.

Now, let's get our little gripe out of the way first—the proprietary micro USB connector. "Micro USB are not proprietary" we hear you cry. You're correct, but Razer makes it so that you can only use incredibly slimline connectors or its own one. We can't even blame it on a money-making scheme, as we couldn't find replacement cables available, and the ones for other Razer products are a reasonable price. It is just strange. With a wireless mouse, we often just grab it and throw it in our bags when we leave the office, especially mice with Bluetooth such as the Naga Pro. This enables us to use our normal mouse when working out of office. Great! With a proprietary connector, however, you have to remove the cable from the PC as well, which is often easier said than done. It is time to just go to USB-C and allow us to use one cable to charge our on-the-go items. At least there is a charging dock available for the Naga Pro Wireless for an additional cost.

Now that our little niggle is out of the way we can talk more about the mouse. The battery life is very good—in fact, in the four or five weeks we used it, we charged it fully once after the initial out-of-the-box charge, and it quite easily managed 100+ hours of use after charge. The sensor is impressive, as you'd expect from a PixArt 3389 with a few tweaks from Razer. It tracks very well on a vast number of surfaces, and you shouldn't have any issues at all. Although the mouse is wide, it is comfortable to use in all standard grip types after the initial adjustment period.

The Naga has three very easy-to-swap side plates that enable you to choose between two, six or 12 fully programmable side buttons. Strangely, only the 12-button version is RGB lit—we would have liked to see the others have lighting options as well, but this is more of a personal preference. The 12 buttons are quite difficult to differentiate between, as they are quite small and in a 3x4 grid. However, if you're using them a lot it will soon become second nature. We used the Naga with the six-button setup the most, as it seemed a good compromise between number of buttons and usability.

RAZER SOFTWARE

The Razer Synapse software is simple to use and makes the Naga very powerful, and you can easily program the buttons to your preference. Using a Naga will never replace a keyboard, but in MOBA games in particular, I found myself assigning keys that were usually either accidently pressed or out of reach. The two wireless modes worked as intended with no drop-outs in either 2.4GHz mode or in Bluetooth. There is a nice little compartment to store the USB dongle in behind the side plates too, which is great if you're on the move.

All in all, the Naga is an impressive mouse. We can't fault it too much other than some aesthetic and personal preference points. It used to be that the Naga was a mouse that was aimed at the MMO/MOBA players, but over the years it's evolved to become a mouse for all games. The three side plates make changing the thumb buttons a two-second job, and users who like the shape and don't mind the weight will be more than happy. If you are only into FPS games, there are better options, but if you want a good all-rounder with easy-to-change thumb buttons, then the Naga is for you. **–DAVE ALCOCK**

VERDICT

8

Razer Naga Pro Wireless

⊞ **ALL PRO** Great battery life; fantastic sensor; easily swappable side plates; Jack-of-all-trades.

⊟ **NO GO** Needless proprietary connector; expensive; charging dock $50 extra.

$149.99, www.razer.com

SPECIFICATIONS

Sensor Model	Razer Focus+ Optical Sensor
Max Sensitivity	20,000 CPI
IPS	650
Acceleration	50G
Programmable Buttons	10/14/20
Connection Standard	Micro USB
Battery Life	Up to 150 hours
Weight	0.257 lbs

SteelSeries Apex 7 TKL Keyboard

There are many TKL boards like it, but this one is ours

WITH A RATHER sleek wrist rest and a really nice gun-metal gray aluminum top plate, this board certainly looks the part. A closer inspection then uncovers a scroll wheel and a little button beneath it that can act as volume and media keys, as well as menu navigation for the OLED screen. We have seen OLED screens on SteelSeries products before, and although we know that they are gimmicks, we still like to play with them from time to time and see if there is actually anything useful we can do with them.

We played with multiple apps that work with the OLED screen—some official ones and some third-party. The Discord app is particularly useful, as is the System Monitor, and you can of course put your own animated GIFs on the screen. Our favorite app, however, is a third-party app that enables you to see what is playing at a glance, and this is where we believe OLED screens can actually be useful. The only downside to the screen on the APEX 7 TKL is that it is hidden by the M1-M6 keys, and unless you sit directly over the keyboard it is rather hard to see what is on the screen. This isn't a major issue at all, however—as mentioned, we see the screen as just a silly additional extra on the keyboard that is fun to play with.

We also noticed that there was no Print Screen key. The aforementioned OLED screen takes the space where this key is usually found. This isn't uncommon on smaller boards, and usually you can use Fn+ a certain key that will be programmed as a Print Screen key. We looked for this, but nope. Nothing. So we fired up SteelSeries Engine 3, which is a great bit of software. We were hoping that SteelSeries hadn't overlooked this major flaw, and we were very relieved to find that it is very simple to set any key to have a second function in combination with the Fn key, and we spent the next few hours simply playing around with those.

With 60 percent keyboards, you can often have multiple layers and/or are able to reprogram all the keys—usually it is done in a convoluted way, but not in this case. Click "Config, Meta Bindings," the key you wish to set to do a secondary function with the Fn key. Then, select it from a ridiculous number of options that have been segregated in a way to make it easier for you to find what you want to do, and you are away. We did this with Fn+P, so now that takes screenshots. You can also record full macros and set them to be activated with the Fn key. It really is fantastic, and we haven't been hands-on with any other keyboard that makes it this simple.

DOES IT ALL

We haven't mentioned much about the standard features of this board, and that's because they're as expected. There is no key chatter, the lighting is great, the macro keys are easily programmed, and there are cable channels to keep the desk tidy. There is also a USB 2.0 passthrough on the rear of the keyboard.

It is hard for us to say this about an off-the-shelf board with no modifications, but we really do love the Apex 7 TKL. Sure, the OLED screen is more of a novelty than anything practical, and the keycaps are ABS rather than PBT, but the keyboard just does everything that we would want, and a little bit more.

Yes, the Corsair K65 can be had for around $30 less, and sure, it does do most of the same things with the same switches, but the software for the APEX 7 is just easier to use, and the whole solution feels better. Hopefully, we will soon see similar options from competitors to try and take the crown from SteelSeries! **–DAVE ALCOCK**

VERDICT
9
KICK ASS!

SteelSeries Apex 7 TKL

+ HARD AS STEEL Great software; fun features; excellent back-lighting; meta bindings make reconfiguration of the board very easy.

− FLIPPY FLOPPY ABS keycaps; screen somewhat hidden.

$129.99, www.steelseries.com

SPECIFICATIONS

Form Factor	TKL
Switch Type	Cherry MX Browns
Switch Durability	100 million
Media Keys	Programmable
Connection Standard	2 USB 2.0 cables (one for passthrough)
Battery Life	N/A
Weight	1.7lbs
Dimensions	5.48 x 13.99 x 1.59 inches

Thrustmaster eSwap Pro Controller

Just too many steps away from greatness

© THRUSTMASTER

ONE THING that will always endear a product to us is the presence of a little screwdriver in the package. It was true of AMD's Threadripper CPUs, and Thrustmaster's eSwap Pro pulls the same trick to open our hearts, with a simple metal Phillips-head model that might be small enough to repair your glasses with.

The purpose of the screwdriver is to remove two tiny screws on the gamepad's triggers, so that they can be removed and replaced. The same is true of almost every other moving part of the controller, apart from the face buttons and bumpers. The screwdriver's other end fits nicely into a slot in the D-pad to pull it out, while the analog sticks are big enough to grasp with your fingers—but you're not going to want to lose that precious screwdriver.

This controller is heavier than an Xbox One controller, and it has to be the first time that an old-fashioned wired connection has been celebrated as a feature (zero lag!) in a world turning wireless. The micro-USB cable provided is a decent length, and has one of the biggest plastic shrouds around its plug we've ever seen. The eSwap is a touch broader than the MS pad—more like a DualSense—and feels chunky and solid in the hands. Its default side-by-side stick arrangement mirrors Sony's preference too (as do most of the buttons; the pad is licensed and compatible with PlayStations, though there's an Xbox version too), but you can slip the stick and D-pad out and swap them around.

Changing the modules is quick, easy, and dare we say fun. A magnet holds them in place, giving a satisfying "snick" as they slip home. Additional modules are plug and play, so there's no messing about restarting or reconnecting once you've swapped one. We were provided with a set of replacement parts in livid orange to test this out, complete with "next generation" sticks.

The thumbsticks that ship with the controller are fine, though they make a strange "pop" sound every time you begin to move them. They've got good resistance, and feel very like the Xbox One equivalent, just with more texturing on their heads. The next-gen models, however, are a revelation. Their slightly longer shafts and thicker heads mean that anyone who likes to push from the edge rather than keep their thumb firmly on top will feel very happy. The orange color of the add-on parts, however, despite looking so vibrant when taken from their own box, is somewhat deadened once slotted into the charcoal body of the controller.

Elsewhere, the face buttons are PlayStation standard, and click rather loosely. You can hear the spring underneath them, and it's a shame these can't be replaced. The cross-shaped D-pad feels the same, wobbling in its fixings as if not quite installed properly. Replacing it with the add-on orange version didn't make things any better. It's a poor relative of the D-pad on the masterful DualSense, and has more give in it than the one on the Xbox One pad. The triggers have good resistance, and can be swapped, but doing so changes nothing but the color. The four additional buttons on the bottom have very little travel, and while they're easy to reach with the middle fingers, we wonder how much utility they will actually give in the long run. Most games are already pretty good at mapping controls to the pad.

The management software—Thrustmapper—tries to help (Chrome had a little bit of a problem with this, saying it couldn't be downloaded securely, but we persevered and it turned out okay in the end), enabling you to set up profiles for particular titles and switch the behavior around. At least, it would if we could get it to work. Upon initial installation it refused to let us create a profile, rejecting every name we chose, then when restarted it threw "invalid configuration" errors, even though we'd put the controller back in its default state.

Thrustmaster almost has a great controller here, if you can deal with the wired connection. It has an exceptional feel, especially with the next-gen sticks installed, but it's let down by the looseness of the other buttons, the high price, and poor software. **–IAN EVENDEN**

VERDICT 6

Thrustmaster eSwap Pro Controller

+ SWAPPER Ingenious swappable parts; feels good in the hands; next-gen sticks are top quality.

− FLOPPER Buttons feel loose; D-pad is especially bad; wired connection; software has some issues; expensive.

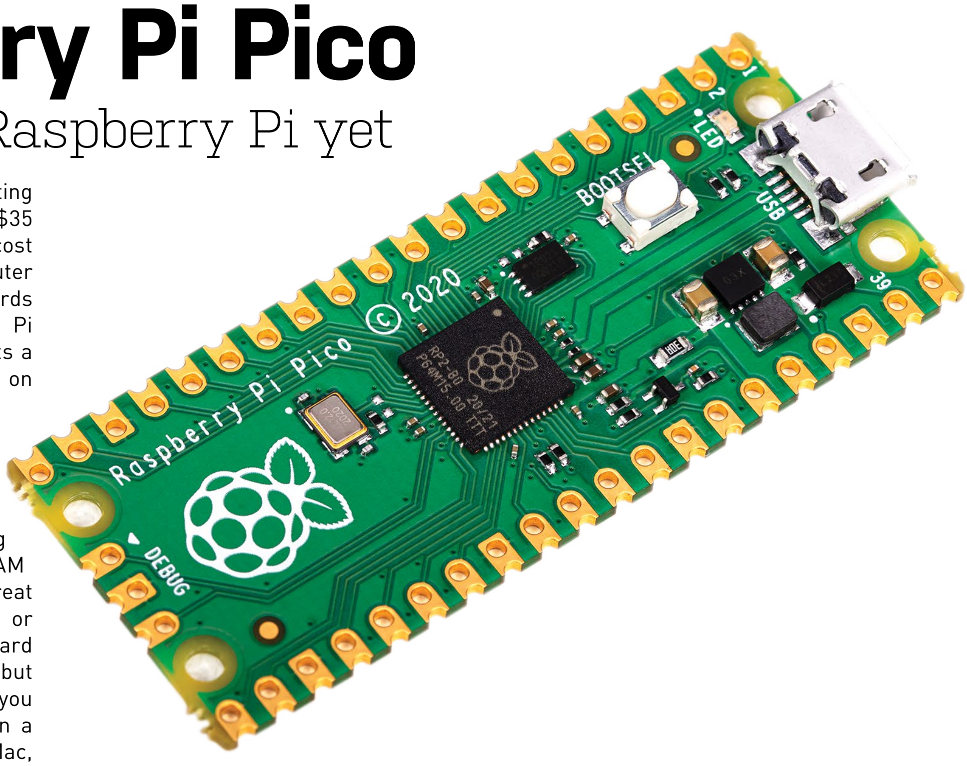
$179, https://eswap.thrustmaster.com

SPECIFICATIONS

Compatible OS	Windows 10, PlayStation 4
Interface	USB 2.0
Dimensions	9 x 3 x 7.6in
Battery	None
Battery life	n/a
Accessories	Screwdriver, soft bag
Cables	6.5ft micro-USB
Weight	13.6oz

Raspberry Pi Pico

The smallest Raspberry Pi yet



© RASPBERRY PI FOUNDATION

RASPBERRY PI has a history of disrupting the status quo. In 2012, the first $35 Raspberry Pi emerged as a low-cost option in the single-board computer market that was dominated by boards in excess of $100. The Raspberry Pi Pico, the latest in the range, disrupts a different part of the market, taking on microcontroller boards like Arduino.

Available for an MSRP of just $4, the Pico is powered by Raspberry Pi's own custom silicon, the RP2040 SoC, which features an ARM Cortex M0+ processor running at up to 133MHz, with 264KB of SRAM and 2MB of on-board storage. A great choice for robots, weather stations, or other electronics projects, the board doesn't run a full operating system, but instead launches programs that you write in either MicroPython or C on a host computer (that could be a PC, a Mac, or a regular Pi) and upload to it.

On paper the Raspberry Pi Pico is not even a rival for the Raspberry Pi Zero, which itself costs only $5, but the key difference between the two is that the Pico is not a Linux computer—it is a microcontroller like Arduino, and is better for many projects. It could even work in conjunction with a regular Pi.

Just like the larger Raspberry Pis and newer Arduino boards, the Pico uses a 3.3V GPIO. This could be seen as a negative, but many components can be used with 3V and 5V voltages, and those designed for 5V can still be used with 3V via a voltage divider or a logic level converter board.

PICO POWER

The Raspberry Pi Pico is an efficient board for embedded projects. Compared to a typical Raspberry Pi, the Pico consumes much less current—granted, it is a microcontroller with none of the overheads that a computer brings. In our test we powered a Raspberry Pi Pico running 12 Neopixel LEDs at full brightness from a 5V power supply. We recorded 140mA current draw, and 0.7W! This is remarkable: a Raspberry Pi 4 running idle with nothing connected would run at 4-5W.

Talking of power, we can power the Raspberry Pi Pico via the micro-USB port, or we can use the VSYS GPIO pin to provide power between a range of 1.8V to 5.5V. There is no battery charging available via the Pico, so an external circuit would need to be used.

The Pico is made to be embedded into a project. The price, size, and design of this board make it a viable Arduino alternative. Robots, Neopixel-powered light displays, and learning electronics are all made possible with the Pico. So, while a fully fledged Raspberry Pi, such as the Zero, is more powerful, there are many reasons why you'd want the Pico for certain projects. It boots quickly and doesn't require a safe shutdown when powering off, so you can just turn it on and go. It uses considerably less power than a Raspberry Pi, and it has on-board analog-to-digital conversion, something all other Pis lack.

Where the Pico falls short is wireless connectivity. There is a complete lack of Wi-Fi and Bluetooth with the Pico, and this limits what can be achieved. Sure, we can add wireless connectivity via an external component, but that would require a little more knowledge to get working. The ESP32 and ESP8266 run at a similar price point to the Pico but feature Wi-Fi, so if you need Wi-Fi, they are still the boards to look to, for now.

The Raspberry Pi Pico, then, is an interesting piece of kit. It is more Arduino than Raspberry Pi, and so the lines are a little blurry. If you need a Raspberry Pi in a small space with Wi-Fi or Bluetooth, buy a Raspberry Pi Zero W. If you want to embed a control board into a project and have it work quickly and reliably, then the Pico is for you. For an official and well-supported entry into ARM Cortex M0+ boards, the Raspberry Pi Pico is hard to beat. **–LES POUNDER**

VERDICT

8

Raspberry Pi Pico

+ PI IN THE SKY Super cheap; tiny; easy to use; built-in ADC.

− PI FACE C workflow can be tricky; no built-in Wi-Fi; no 5V output.

$4 www.raspberrypi.org

SPECIFICATIONS

SoC	RP2040 microcontroller chip, Dual-core Arm Cortex M0+ processor @ 133MHz
RAM	264KB
Comms	N/A
GPIO	26x multi-function 3.3V GPIO pins, 2x SPI, 2x I2C, 2x UART, 3x 12-bit ADC, 16x controllable PWM channels, 8x Programmable I/O
HDD	2MB on-board Flash
Power	Micro-USB Port or VSYS GPIO pin
Size	2.0 x 0.8 inches

THE END IS NEAR

Clearly, all is not well in the world CD Projekt has created.

Body modding is all the rage.

Cruising around is one of the big highlights—if you avoid the bugs.

Night City is packed with sleazy characters.

Killing enemies can be buggy—sometimes they twitch and move on the floor.

ACTION ROLE-PLAYING

Cyberpunk 2077

Stepping out in Night City, hoping not to get bugged

WE SHOULD HAVE expected a wild ride. Eight years in development, a team of up to 500 people, Keanu Reeves. You'll have read about the rest: the delays, the crunch, the controversies over representation, the game-breaking bugs, Sony pulling it from the PlayStation Store because of its PS4 performance, the lawsuits. Could it ever live up to the hype on PC?

Kinda. Maybe. Let's go through our first steps with the game by way of an example to support that nebulous summing-up. We start the game a few days after its launch expecting a crash to desktop at any moment, because that's what we've read will happen. It doesn't. We didn't get an early review code, so it's had one patch already by this point, and another comes in halfway through our review process. We go straight to Settings and mess with the graphics options, eventually settling on the High preset at 1080p, as our RTX 3080 card hasn't arrived so we're using a 1070Ti.

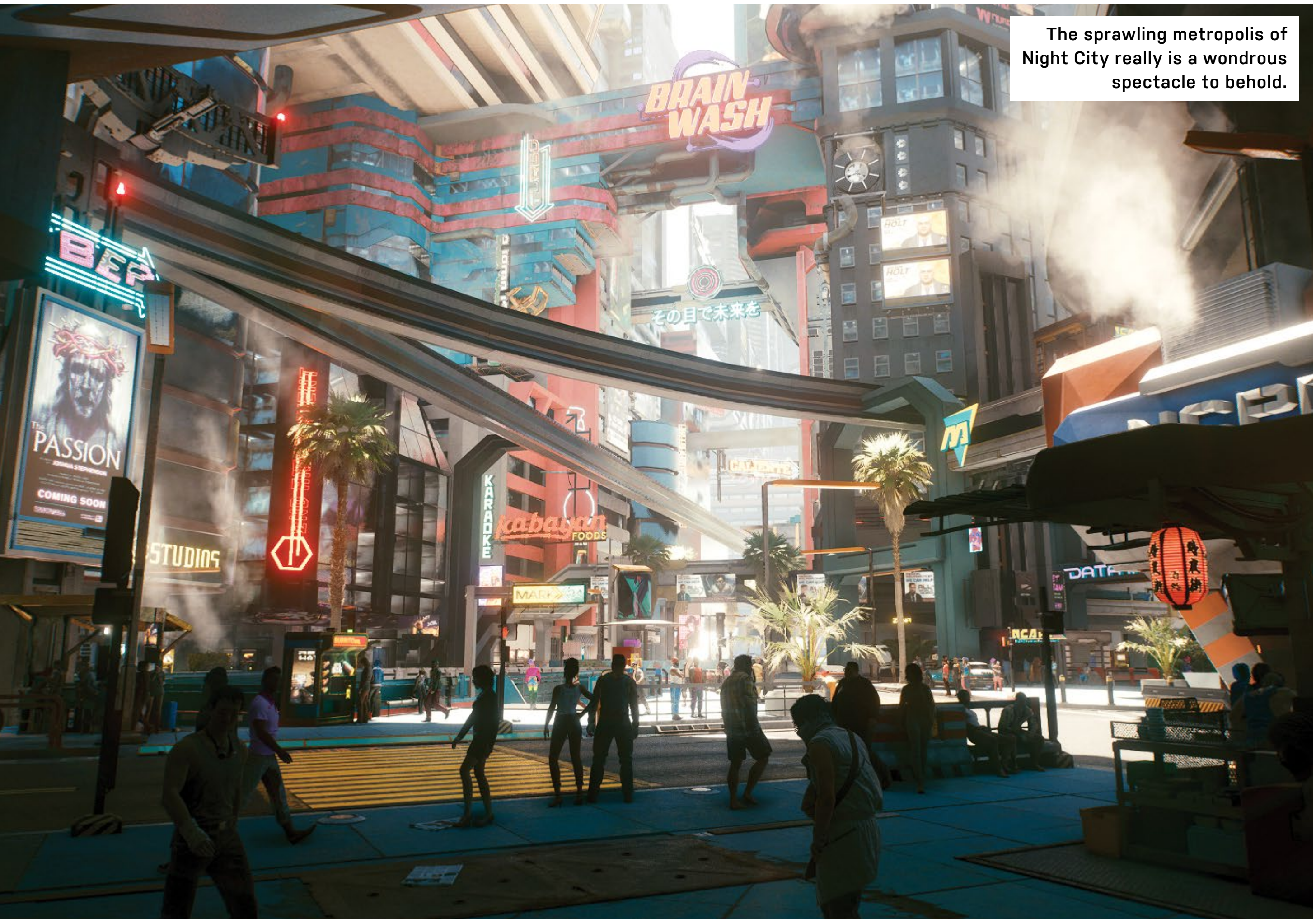
Next comes the character creator. Protagonist V is entirely custom, and we know there's a bug that leaves penises hanging out of pants on male-bodied characters, so we try that out for a laugh before switching to a female character model (we are immediately presented with her breasts), and hammering the random button until we settle on a green-haired, suitably weird avatar for our Corpo. There are three starting classes in *Cyberpunk*. Ours is a businesswoman from the world of skyscrapers, fully automated transport, and corporate espionage. The alternatives are Street Kid or Nomad, but they don't change much beyond the prologue.

Everyone in Night City goes in for body modification in a big way. There's no such thing as appropriate business dress—you can have spiral-tattooed eyeballs and still get a job as a CFO, it seems. Being part machine also doesn't impair your dancing, and the implantation of your cellphone into your brain is just as irritating as you'd expect.

At this point we turn the graphics preset up to Ultra, as we've been getting a steady 60fps, and that's unnerving—the framerate quickly drops to the 40s. Back to work, and our Corpo is given a mission and gets to wander around the sort of modern office building we can only dream of. It's very dark inside, though, which makes us worry for the eyesight of all the workers staring at screens. We needn't have—they've all had their eyes replaced, of course. Some are even wearing sunglasses. The mission goes bad, and we find ourselves on the run with Jackie, apparently a good friend but who seems perfectly set up to betray us at some point–this isn't our first rodeo. There's a cool montage sequence set to excellent music showing Jackie and us getting into scrapes and doing some shooting, but we're not in control. We do some "VR" training missions on combat, stealth, and hacking, and everything works the way it should. Where are these bugs we've been told about? When we take over again, we're embarking on a rescue mission.

Sneaking into a building, Jackie's guns stick to the doorframe, and he carries on in without them. This floating

© CD PROJEKT



The sprawling metropolis of Night City really is a wondrous spectacle to behold.

disarmament does not in any way affect his lethality—the bullets issuing from his fingers are equal to those his pistols can fire. We're all using pistols at the moment, because it's the beginning of the game, but what's more concerning is that the bad guys we're either taking down stealthily or shooting in the head don't seem to die properly—they continue to twitch and rhythmically jerk as if part of Galvani's frog experiments. We clean the baddies' apartments out of whatever we can find, from cash to stimulants to their ashtrays, because that's a filthy habit.

In the end, we kill a guy with a massive gun (we pick it up, but it completely vanishes from our inventory) at the top of the block, rescue our target (the game is careful to show us her breasts too), and then leave in a car. V's car only allows us to see a thin slice of the remarkable city CD Projekt has conjured, its high dash and low roof forcing the widest possible aspect ratio. We watch the police go about their business, talk our way through a checkpoint, and then V is finally home.

Her apartment is bland, especially if you compare it to that of Adam Jensen in the more recent *Deus Ex* games, where it gives an insight into his character. We don't learn much about V from where she lives, other than, in common with other videogame protagonists, she owns multiple copies of the same book. Even though she is clothed, the mirror in the bathroom displays her nude, and we learn that she favors the full Hollywood wax. The ragged jacket we stole while on the rescue mission seems like an armor upgrade, but we can't work out how to put it on. Eventually, we follow the plot cues and go to sleep.

THE FOLLOWING DAYS

That was our first contact with Night City. Over the following days, we marvelled at its beauty, pulled faces at its seediness, wondered which century some of its attitudes had come from, and spent ages admiring how it works and using Photo mode. We were pulled through it by a plot that doesn't give up, and which has some moments of remarkable writing. And we accidentally infected our brain with one of Keanu Reeves' least likeable characters. The city itself is a towering achievement, the missions you go on in it more reminiscent of *GTA* than *Deus Ex*, and the bugs are rife, from NPCs holding invisible... things... to cars stopping dead when you get out of them at speed, or twirling through the air and being thrown across a road while just trying to interact with a door. After all that, we're left with one consoling thought: *The Witcher 3* was something of a mess at launch too.

–IAN EVENDEN

VERDICT
7

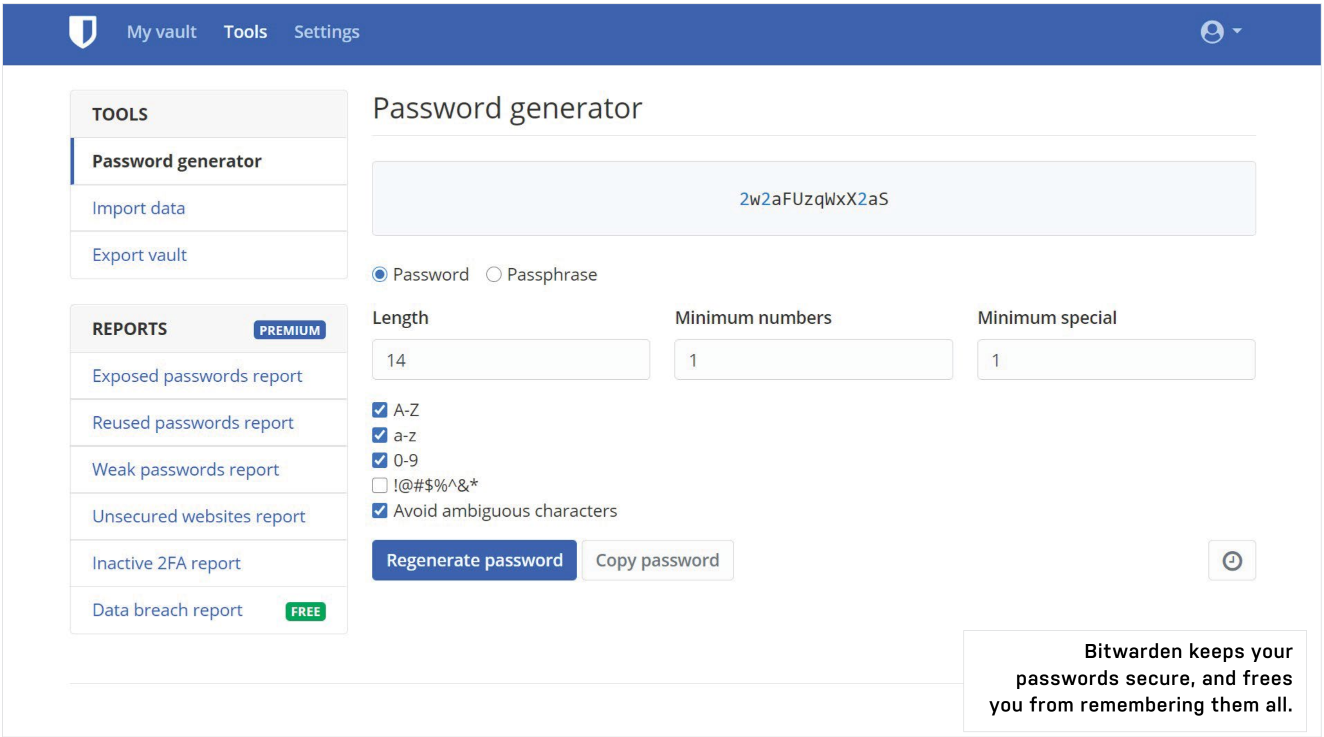
Cyberpunk 2077

PUNK A spellbinding city populated by fantastic freaks, and with a dark side to die for.

DUNK Too much goes wrong; Reeves' character is loathsome.

RECOMMENDED SPECS CPU, i7-4790 or Ryzen 3 3200G. RAM, 12GB. GPU, GTX 1660 Super or Radeon RX 590

$60, https://www.cyberpunk.net, Rated M



Password generator

2w2aFUzqWxX2aS

● Password ○ Passphrase

Length: 14
Minimum numbers: 1
Minimum special: 1

☑ A-Z
☑ a-z
☑ 0-9
☐ !@#$%^&*
☑ Avoid ambiguous characters

Bitwarden keeps your passwords secure, and frees you from remembering them all.

© BITWARDEN

Bitwarden vs LastPass

The winner takes it all (and hides it) in the battle of the password managers

PASSWORD MANAGERS are, we think, generally a good thing. Remembering adsofpjdp is one thing, but also committing 4256p4m2glm! and paLsdKfnk26& to memory is quite another. Keeping your passwords strong and changing them regularly is important these days, when you can check on a website whether or not you've been "pwned," and Chrome harasses you with your unfeasibly large number of compromised passwords.

Web browsers, the front line in the war between password and jailbird, have been able to remember your passwords for a while now, and can generate strong passwords that you'll never be expected to remember. This is fine until you try to log in on a different system, or using your cell phone, and have to dig in the browser settings to view the password that it recorded for you.

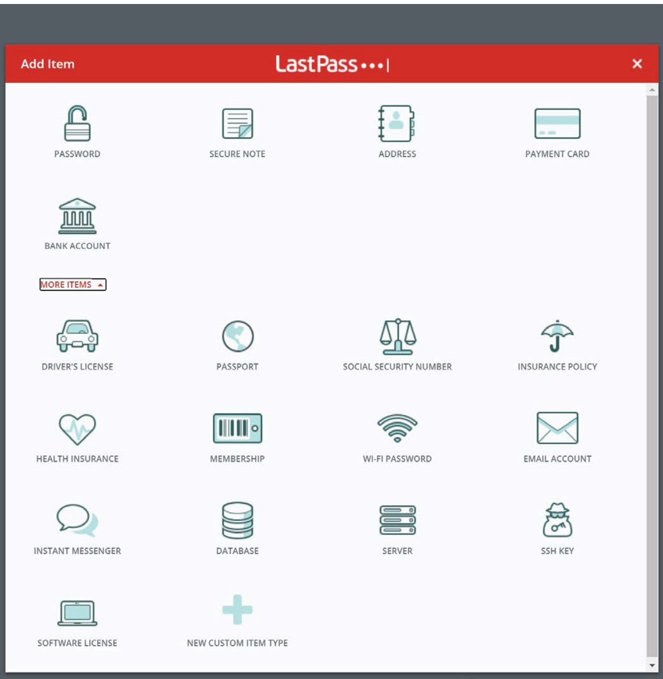
There's another benefit of password managers: they tend to come backed with some sort of internet security suite or browser plugin. They also make it easy to manage your passwords, syncing across devices, generating new ones, and hiding everything behind a master password—which is the only one you need to remember. You can also use them to hide encrypted notes, too.

Of course, the downside of this is that they're massive targets for password thieves. Once they've compromised your master password, your entire digital life is laid open. It's worth, therefore, making that master password as complex as you can possibly cope with, changing it regularly, and never reusing passwords. There are also services, such as some banks, that don't support their use, and if you're caught with your banking details in one you may not get a refund if you're a victim of cybercrime.

Two of the market leaders in password-management software are LastPass and Bitwarden. Both are available for free, though they maintain premium subscription tiers if you need the additional features they can bring. The free apps, however, contain all the functionality you'll need as a one-person user, and only become limiting if you want to roll them out across entire organizations. You can store an unlimited number of passwords in both, and sync them across devices. They both generate random passwords when you sign up for a new service or want to change an existing password, and you can use them to encrypt information, such as bank details or credit card numbers.

Bitwarden is open source, which means it has faced external scrutiny from security experts, while LastPass is not. This doesn't mean there's anything wrong with LastPass's security, of course—it takes part in security audits—and neither app has reported a full data breach, though LastPass has been the target of some minor ones. LastPass offers a hint for your master password, which can save you if you've forgotten it. Bitwarden does not. Both apps offer plugins for major browsers—Chrome, Edge, Firefox, Opera, and Safari. Bitwarden goes one further and plugs into the, ahem, "privacy-focused" browser Tor, while LastPass works nicely with Internet Explorer. These plugins can be used to auto-fill identity fields within webpages, as well as manage your password database via the web interface.

Both services also come with desktop apps, although it's notable that Bitwarden's doesn't support two-factor authentication, and doesn't



LastPass is a capable, secure password manager, with a useful auto-change feature.

© LASTPASS

have the random-password generator or password-sharing abilities of the LastPass app. Both services use separate authenticator apps, however.

The award for user-friendliness has to go to LastPass, as its app and web interface are virtually identical, meaning you only have to learn how to use it once. Both managers use AES-256—the only public security standard approved by the NSA—against which there is no known practical attack strategy that doesn't use a side-channel or some additional knowledge of the key.

Setting the apps up is a simple process. If you've got passwords stored somewhere, such as in Chrome, then they will import them for you. LastPass's Security Challenge feature regularly reminds you to change passwords that are overdue or weak, and there's an auto-change feature that can rattle through multiple password updates quickly— an extremely popular feature with users. LastPass also has recovery options if you lose your master password, sending one-time passwords to trusted email addresses. Bitwarden doesn't offer this—any passwords you store on its servers are accessible to you alone through the master password, so if you lose it or it becomes compromised, then you'll need to rebuild your entire password database.

Bitwarden has one feature you won't find in many other places: your password vault doesn't have to be stored on its servers. This is likely to be of more interest to corporate users (it's only available through the Enterprise subscription tier), but the ability to keep your passwords under your control on your own server can be an attractive feature. Both apps offer secure password-sharing between two users as part of their free tier, which scales up through their Premium and Enterprise tiers, and both offer a small amount of encrypted file storage too, as long as you're a subscriber.

It's worth pointing out again that both apps have a free tier, so it's perfectly possible to download them both, get them set up, and choose which one suits you best with no cost other than a little bit of your time. We're big fans of Bitwarden, but using either app is still better than using neither and trying to remember all your passwords, which inevitably leads to reused, weak passwords, or other security flaws. Password managers are also more secure and flexible than getting your browser to remember them.

Pricing is very close, with LastPass's tiers being slightly more expensive each month by a buck or so. You may find, though, that you get more for your money with LastPass if you're going to go for one of the business-oriented tiers.

Either way, a password manager is a valuable addition to your enterprise, and anyone who uses passwords online can benefit from one. These apps are so similar that it will come down to which has a feature you like, or just personal preference as to which one you ultimately choose. **–IAN EVENDEN**

VERDICT
8

Bitwarden

+ SAFE Open source and externally audited.

− CRACKED Lags behind LastPass for several features.

RECOMMENDED SPECS (for desktop app): CPU: 64bit dual-core RAM: 4GB.

Free for personal use, https://bitwarden.com

VERDICT
8

LastPass

+ VAULT Highly secure; available on all devices.

− HACKED Has had brushes with data loss in the past.

RECOMMENDED SPECS Runs on any PC that can run a supported browser.

Free for personal use, www.lastpass.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Antivirus Roundups
> Photography PC
> Security Woes

NAS OS Installation?

Hi Zak, I've been an avid reader of the mag since the Boot days. Loved your article on the Super Storage Station.

Has *MaxPC* ever done an article on how to install a NAS or Server version of Windows software on a machine? That's what I really need—some hand holding on the OS side. I can install client Windows fine. It's the server side capabilities where I'm a newbie. **–Larry Gagliani**

EDITOR ZAK STOREY RESPONDS: Hi Larry, Thanks for getting in touch. It's funny you should bring this up! I've actually got this penned in for the next issue. Nick Peers is going to be writing a fairly in-depth eight-page feature for us on how to set up your own NAS/Server in Windows, and alternative solutions to that as well. So hopefully you should see something about that very soon.

I was hoping to get it in a bit sooner (for this issue technically), as Nick's actually built a new system for himself in December specifically for this very feature. But unfortunately my plans got a bit scuppered for our Feb edition. Christian's had to take some significant time out due to major health concerns, and I had to self-isolate as I contracted COVID-19 and couldn't attend two build photoshoots. It's all very frustrating!

Antivirus Roundups?

Hey Zak, Happy New Year and great job at *Maximum PC*. I really like your approach, and your writing style—very informative but with an ever-present friendly vibe. Keep up the great work!

It's been a while since a thorough review of various anti-virus/malware protection products. I'd like to suggest a refresh in the coming months if possible. We've used Norton 360 for years and it seems fine, but our free subscription is ending soon and we're wondering whether to just go with Windows Defender or pony up for another product. **–Tim N**

EDITOR ZAK STOREY RESPONDS: Hi Tim, Thank you for the compliments, it means a lot. Honesty's the best policy I usually find.

It's interesting that you should bring up the anti-virus thing, clearly great minds must think alike, because we've just done something like that in our February issue. In the software head-to-head review we do at the end of the reviews section, Nick Peers has done a sort of three-way roundup between Bitdefender, Avira, and Windows Defender, which is all based off of a combination of in-house and external testing. He really knows his stuff when it comes to things like this.

We haven't included Norton in this one, but I agree that it's something we should do more often. I'll pen in another one for the April 2021 edition, perhaps with McAfee and Norton.

Photography Parts?

Hi all, From the healthcare front lines, I hope everyone there is well and staying safe.

My wife is an avid photographer and a heavy user of Photoshop and Lightroom. She's also starting to get into video editing. Her current PC is dated and getting a little tired so I want to build her a new one from scratch, specifically geared toward photography and video editing.

I've built many PCs over the years, including those with custom cooling loops, but I've never built one specifically for photography and video editing. My understanding is that you would choose different components for these types of builds?

Would you guys have any hardware recommendations for me or... would you consider doing an article on a hardcore photography and video editing build? For me, I'm brand agnostic (Intel vs. AMD) and while I want to keep costs down, that's not my main concern... performance is. Thanks guys. **– Dave**

EDITOR ZAK STOREY RESPONDS: Hi Dave, this is a good one. Photography is a lot less intensive on system resources than it used to be thankfully. However, videography does take a bit more—it all depends on how far you want to take it, and how much you want to invest. I find it's an argument really about whether this is something you're going to actively profit from, or is it just more a hobby? Answering that question will determine a lot of factors on how you should invest.

Regardless, you'll always be better off in these scenarios (especially videography work) with more

↘ submit your questions to: comments@maximumpc.com and faster memory, and more memory channels. It's all about increasing bandwidth in that area, and that can have dramatic effects on video-render times in particular. And of course more cores helps a lot here too, preferably with high single-core performance.

If I was building a system for a friend who was into videography, and money was no object, I'd be looking at going with a Threadripper 32-core processor, 128GB of DDR4 at probably 3,000MHz or more (depending what the motherboard supported), and a super-fast PCIe 4.0 SSD (probably 1TB at a minimum) so I've got a quick desktop to work from with massive files, and then likely a separate dedicated network NAS with a 2.5Gb connection for all of my media storage. Then on top of that I'd be looking for stuff that particularly had endurance in mind that you don't have to think about too often. So I'd stay away from liquid cooling in its entirety, and probably look at a Noctua air-tower—specifically one with industry applications in mind. Something like this https://pcpartpicker.com/list/PwL4j2. Now that's $5,300 at the time of writing, which is excessive (stock problems aren't helping here), but it should give you a good idea of the sort of things you should prioritize if you're looking at builds like that.

A good alternative would be a Ryzen 7 5700X setup and 64GB of DDR4. If you're just rendering videos and not editing them massively then even 32GB could work fairly well. As for photography, any modern-day system can deal with that quite easily—as long as you've got 16GB of RAM and at least six to eight cores, you should be more than fine. But again it's all dependent on the scenario, and who you're building it for really.

[CORRECTION]

SCREEN MIX-UP

Last issue, we had a visual mishap occur in our Gear of the Year feature. In the print edition, on page 22, the image used for the ViewSonic Elite XG270QG was actually an image of the ViewSonic VP2785-2K. I'd just like to apologize if there's any confusion, sadly we missed it on our PDF checks, and didn't see it until the magazine had already gone to press. Both screens are still fantastic monitor choices, however the Elite XG270QG slightly edges out the VP2785-2K thanks to its Nano IPS panel and gaming-oriented features. **–Zak Storey**

Sandbox Mode?

Zak, Long time reader and even though I am not a gamer, I really enjoy the magazine, especially anything dealing with software. I am finishing the Jan 2021 edition and would like to suggest an article on WiFi-6E which could be a real game changer.

I would also like to direct a comment to the doctor who also does a fantastic job. In the Jan 2021 issue someone asked about the safety of free software and I think he should have added that with Win 10 Pro you can use the built in sandbox to safely download and play with any software before you install it on your primary system. I know he knows this and maybe he had space limitations, but IMHO it was an incomplete answer and this info might be helpful to some. I also believe the sandbox is a really good reason to pony up the extra bucks for the Pro version of Windows 10.

Keep up the great work and be safe. **– Ted**

EDITOR ZAK STOREY RESPONDS: Hi Ted, Thanks for writing in, that's definitely something I feel like we haven't covered. We typically try and stay away from networking where we can, as so much of it is dependent on your infrastructure, which varies massively from state to state, so it can be a bit alienating sometimes for some of our readers. But I think you're right, 6E is a big deal, and we haven't covered that in enough depth. I've got some writers in mind who might be up for the challenge, so I'll likely pen that in for our next issue, thanks for the recommendation!

I forwarded this on to Doc! He loves receiving emails like this, and so do I—anything that challenges the crazy amount of knowledge in that brain of his. I asked whether he'd like to include this in the Doctor section next issue, but being the honorable Doc he is, he didn't want to steal your thunder! In fact he'd never even thought to use Sandbox like that either.

Internet Security?

First I want you to know I love the magazine, even though most of the articles are way over my knowledge. But I am learning. Need your opinion. What would you use to surf the internet yet protect your privacy and offer security?

I'm thinking:

- Browser.... Dissenter
- Search....... DuckDuckGo
- OS .... Windows 10
- VPN .... Zenmate
- Email......... Protonmail
- Security .... PC Matic

What would you use (or do use)? **– Stephen S**

EDITOR ZAK STOREY RESPONDS: This is a tricky one for me. I really keep things quite simple on my personal rig. This is going to sound insane to a lot of people, but I actually use very little on my PC. I don't have backups, and I'm oddly not nostalgic for photos or anything like that. So the way I keep safe and protect my privacy in the digital world is by not interacting with it too much. I recognize that it's something that's more habitual than it is actual advice, but it's kind of true. If you take a step back and look at how you interact with the world, it can give you a good idea as to where your privacy and security holes lie, and therefore you can work to mitigate that risk.

Because I swap rigs so often, I don't have anything on the PC that's necessarily valuable to me. And so, if it gets infected, or if I get some ransomware (I never have, but you never know), or if there's a software bug, I just flatten the entire thing and start again, and I'm no worse off than I was 30 minutes ago.

I also flip-flop back and forth between programs too. Personally I use Firefox or Google Chrome for my browser, with HTTPS Everywhere, uBlock Origin, Disconnect, and LastPass as extensions. My OS is Windows 10 (although I do use macOS occasionally as well). For a VPN I use ExpressVPN (and I can set that up to operate on my router too, to cover all the devices in my house if I want to), and Gmail for email.

And as for security, I actually just rely on Windows Defender, although if I had to pick one, I would probably go back to Bitdefender, as I used that for years before I joined *Maximum PC.*

THE BUILDS

BUDGET

THIS HAS BEEN one of the most difficult times to talk about hardware, especially when it comes to pricing up builds. To give you some perspective on how the shortages, scalpers, and miners have put a strain on this industry, our AMD budget build went from $693 last issue to $1,092 this issue, with identical parts. That's a $400 increase (or 58 percent) in cost in the space of a month, for exactly the same components. And even with extensive changes to that build, we've still only managed to mitigate the price increase to $157 more. But for that we've lost access to eight PCIe graphics lanes (So we'd be running 8x PCIe 3.0 instead of 16x PCIe 4.0 for the GPU), two cores, four threads, and we have 25 percent of the L3 cache we did have, and no access to PCIe 4.0 either.

However, we've kept the motherboard's chipset the same, so if stock does come back we should be able to upgrade that processor to a Ryzen 3 3100 at a later date, but it's actually really difficult for us to recommend buying this build right now. If you need a PC, and we mean *desperately* need a budget PC, then this is a good recommendation. But honestly, hang tight and hopefully by summer things will have worked themselves out.

Sadly it's a similar affair for Intel too, although we've managed to dodge some of the more radical hardware changes that our AMD build has suffered—though prices have still gone up by $168. We've had to swap the Core i3-10100 to the F variant, so we lose integrated graphics, and we've managed to grab a 1660 GPU. A lot of the components are identical between these two rigs this issue, mostly because they're just the cheapest we could get our hands on in a vain attempt to mitigate that ridiculous price increase.

If you do need to save a little extra cash, you can currently pick up a 4000D (the non Airflow variant) for just $75. It comes with all the same features, same interior layout, and is easy to build in. The only downside is that the front panel is solid.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W EVGA 450 BR 80+ Bronze	$42
Mobo	ASRock B450M-HDV R4.0 M-ATX **NEW**	$68
CPU	AMD Athlon 3000G **NEW**	$94
GPU	Gigabyte GeForce GTX 1660 6GB **NEW**	$330
RAM	16GB (2x8GB) OLOy DDR4 @ 3200 MHz **NEW**	$66
SSD	250GB Samsung 980 Pro M.2 PCIe 4.0 SSD	$90
HDD	1TB Seagate Barracuda 1TB 7200 HDD **NEW**	$40
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$850**

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W EVGA 450 BR 80+ Bronze **NEW**	$42
Mobo	MSI B460M-A PRO Micro-ATX	$80
CPU	Intel Core i3-10100F **NEW**	$117
GPU	Gigabyte GeForce GTX 1660 6GB **NEW**	$330
RAM	16GB (2 x 8GB) ADATA XPG Z1 DDR4 @ 3000 MHz	$70
SSD	500GB Samsung 970 Evo M.2 PCIe 3.0 SSD	$65
HDD	1TB Seagate Barracuda 1TB 7200 HDD **NEW**	$40
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$864**

MID-RANGE

SO, WE CAME into this thinking we wouldn't really change many parts this time around because of the way stock is right now, but inevitably that feels like a betrayal, so we're trying to minimize cost where we can. However, it's proving difficult to avoid, especially if you want to keep performance the same.

Fortunately, across both AMD and Intel, at least at the moment, neither CPU has seen a substantial price increase—no doubt because Intel's about to release new processors, and these are last-gen AMD chips, so there's stock floating around. The memory, GPU, and mobo, on the other hand, most certainly have. In fact, the GPU we used in our AMD build just a month ago has skyrocketed up to an incredible $900. That's $900 for a mid-range, last-gen 1080/1440p graphics card. It's saddening. We found this standard RTX 2060 for around $650, which is still way too much for a GPU of that caliber. Overall, we're $365 up on last issue for our AMD build.

And then we get to the Intel build. To be fair, this is mostly self-inflicted; we swapped out the motherboard to something more at the budget end of the spectrum, but we decided to plump for a slightly more "impressive" (air quotes definitely required) PNY GeForce RTX 2060 Super. It's the cheapest RTX 2060 Super we could find, and it's definitely an upgrade on last issue's 1660 Super. According to Jarred, our resident GPU expert, it has approximately 32 percent more performance at 1080p Ultra for the low, low price increase of just 165 percent compared to last month's 1660 Super.

And so again we end up with the same conclusion: it's just not the right time to buy a system, or even consider upgrading. Scalpers, miners, and stock shortages are pummelling the market into submission, and you'd be far better off waiting it out, as much as that saddens us to say. It's not only modern-gen components that are getting hit hard here, but every element of the industry.

AMD INGREDIENTS

PART		PRICE
Case	Lian Li PC011-Dynamic	$150
PSU	550W Corsair RMx (2018) 80+ Gold **NEW**	$100
Mobo	Asus TUF Gaming X570-Plus	$170
CPU	AMD Ryzen 5 3600	$200
Cooler	240mm Corsair H100x AIO **NEW**	$100
GPU	MSI GeForce RTX 2060 Ventus XS OC **NEW**	$650
RAM	16GB (2 x 8GB) Corsair Vengeance LPX DDR4 @ 3600 **NEW**	$83
SSD	500GB Sabrent Rocket 4.0 M.2 PCIe 4.0	$90
HDD	1TB Seagate Barracuda 1TB 7200 HDD **NEW**	$40
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,608**

INTEL INGREDIENTS

PART		PRICE
Case	Lian Li PC011-Dynamic	$150
PSU	650W EVGA SuperNOVA GA 80+ Gold **NEW**	$95
Mobo	ASRock Z490 Phantom Gaming 4/2.5G **NEW**	$155
CPU	Intel Core i7-10700	$328
Cooler	Cooler Master Masterliquid ML240L AIO	$60
GPU	PNY GeForce RTX 2060 Super 8GB Dual **NEW**	$800
RAM	16GB (2 x 8GB) G.Skill Aegis 16GB @ 2400 **NEW**	$65
SSD	500GB WD Black SN750 M.2 PCIe 3.0 SSD	$65
HDD	1TB Western Digital Caviar Blue 7200 HDD **NEW**	$45
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,788**

PREDICTABLY, THIS ISSUE'S Turbo builds have been just as rough as the others. You can no longer buy an AMD Ryzen 9 5900X at the time of writing, and the 5950X is well into four figures at this point—50 percent above its RRP—so we've had to take a step down and grab the Ryzen 7 5800X instead. We've managed to save $10 compared to last issue with the 5900X, although we've lost four cores and eight threads as well. But then there's literally no alternative there. We've also rejigged things a bit with the motherboard and the power supply in a vain attempt to save some cash here too.

Inevitably, we get to the graphics card situation once more, and this applies to both builds. Similar to just a few issues back, there's just no stock anywhere, of anything, so we've had to realign our sights with an EVGA GeForce RTX 2080 Super Black Gaming. It's not technically in stock yet at the time of writing, but will be within a month or so. And a downside is that it's a "renewed" one. So it broke at some point, EVGA (or a third party) repaired it, and now it's back available for purchase (or pre-order in this case), for just over 50 percent more than its original RRP in 2019.

All in all, we've managed to keep the price increases down on the AMD Turbo build. We've lost the performance of the RTX 3080, and the four additional cores from the Ryzen 9 5900X, but the price has only increased by $272, which almost seems like a win.

In the case of Intel, things are less dramatic. We managed to keep the price difference down to just $233, even with the jump up in GPU. However, everything else has remained resolutely in stock. Without a doubt, those latest Ryzen processors are superior to their Intel counterparts, but it means little if they aren't in stock.

Our best advice right now? If you are looking to invest a little and tinker with things, we'd recommend taking a look at your case, aesthetics, lighting, and cooling. All of these are very much in stock, and at normal prices, so you can have fun reducing your noise levels, overclocking your parts, or brightening up your build.

AMD INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$147
PSU	750W Corsair RM750x (2018) 80+ Gold **NEW**	$135
Mobo	MSI MPG X570 Gaming Plus **NEW**	$169
CPU	AMD Ryzen 7 5800X **NEW**	$540
Cooler	Corsair iCUE H150i Elite Capellix 360mm AIO	$190
GPU	EVGA GeForce RTX 2080 Super Black Gaming (Renewed) **NEW**	$1,050
RAM	32GB (2 x 16GB) Kingston HyperX Fury DDR4 @ 3600 MHz **NEW**	$159
SSD	1TB Gigabyte Aorus Gen4 M.2 PCIe 4.0 SSD	$160
HDD	6TB Western Digital Blue HDD **NEW**	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,705**

INTEL INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$147
PSU	750W be quiet! Straight Power 11 80+ Gold	$120
Mobo	Asus TUF Gaming Z490-Plus **NEW**	$180
CPU	Intel Core i9-10900K	$505
Cooler	NZXT Kraken X73 360mm	$180
GPU	EVGA GeForce RTX 2080 Super Black Gaming (Renewed) **NEW**	$1,050
RAM	32GB (2 x 16GB) Kingston HyperX Fury DDR4 @ 3600 MHz **NEW**	$159
SSD	1TB Corsair MP400 M.2 PCIe 3.0 SSD **NEW**	$115
HDD	6TB Western Digital Blue HDD **NEW**	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,611**

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